REFINING • PETROCHEMICALS • NATURAL GASOLINE

Petroleum Refiner

Gulf Publishing Company

OCTOBER
1957

SPECIAL REPORT–PROCESSOR'S LOOK AT . . .

NATURAL GAS

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For a "Quick Look" at this issue, turn the page . .

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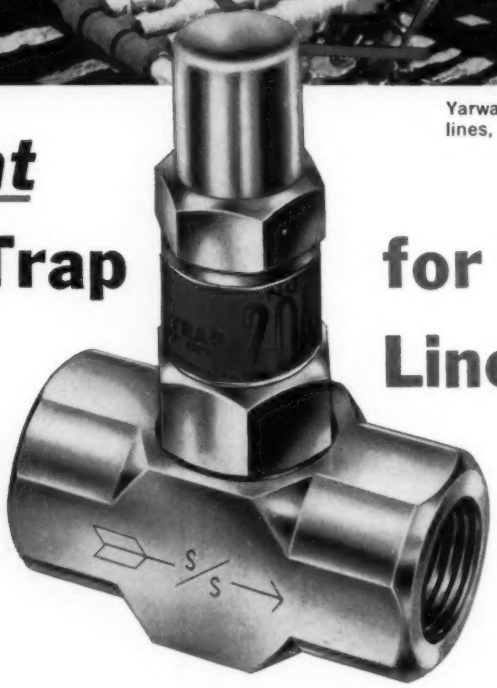

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Petroleum
Refiner
REFINING • PETROCHEMICALS • NATURAL GASOLINE

A Quick Look

at This Issue

These handy digests permit checking ☑ the articles you want to read first.

NATURAL GAS: A Special Report on Its Uses

☐ **Who Will Pay Top Price for Natural Gas—Chemicals or Fuels? . . .** When will it be more economical to make chemicals from other fuels? At what price will natural gas price itself out of the picture? For answers to these and other questions, turn to **Page 100.**

☐ **What's Ahead for Liquefaction . . .** Growing interest in natural gas liquefaction and rising fuel costs seem to go hand in hand. In many areas of the world there is economic justification for this type of fuel. The process techniques, materials of construction and the mechanical problems can be solved. Commercial installations could come within the next few years. Turn to **Page 105.**

☐ **Is Ethane from Natural Gas Economical? . . .** The answer could be YES! Investment requirements are moderate. Standard processes can do the job as well as several new processes. If your gas stream is ethane rich, study this article carefully for a method of increasing your plant profits. Turn to **Page 108.**

☐ **Multicomponent Flash Calculations . . .** Can be made easier than the regular trial-and-error methods. This one gives you good results in less time and covers almost every condition. You'll like this one on **Page 113.**

☐ **How Metals Behave at Low Temperatures . . .** Here's the reason some of the properties of metals are improved at low temperatures while others, such as ductility, may be impaired. Ferrous metals

Please Turn Page ➜

exhibit a sharp loss in ductility at low temperatures while pure, face-centered, cubic metals such as copper, aluminum, nickel and lead are unaffected. For complete details, turn to **Page 119.**

☐ **Automation Today (Part 13) . . .** This example problem uses a shell and tube exchanger to show how analog computers can stimulate refining processes. The equations and electrical circuits are given to make it easier for you to apply the same principles to other processes. Turn to **Page 125.**

☐ **Working Pressure for Tanks . . .** Here is a handy nomograph for determining the working pressure of hammer-welded steel tanks. To have it for your engineering files, turn to **Page 128.**

☐ **Alloy Electrical Material May Be Cheap! . . .** Where there is a need for continuous service, corrosive-resistant electrical materials can be economically justified. Stainless costs 6 to 8 times as much as galvanized steel, and bronze costs 4 to 5 times as much. This article tells how you can use these materials and save money. For complete details, turn to **Page 129.**

☐ **New Ideas to Improve Gasket Performance . . .** The easily replaceable packing and gasket can be made to stand up to the serviceability of the equipment itself to insure continuity of operation. These case histories tell how to get that insurance by engineering your gasket problems. For complete details, turn to **Page 131.**

☐ **Predicting V-L Equilibrium Data . . .** The method presented here will yield V-L data for cases that are not available in the literature nor easily obtained experimentally. This method works well for multi-component mixtures and can be adapted to your computer program. **Page 135.**

☐ **Modern Design of Steel Columns . . .** Here is a new approach to column design for the cases where a moment is applied at the same time the column is loaded axially. For complete details, turn to **Page 140.**

☐ **Select Your Pumps By Specific Speed . . .** And do it faster, of course. Use this method of specific speed to check your process design as well. This is another slide-rule saver for your note book. Take a look at **Page 145.**

☐ **Calculate Condenser Pressure Drop . . .** Actual test data in a heat-transfer pilot plant and a special isothermal test unit were used to develop a new empirical correlation. Using this correlation as a basis, the pressure drop during condensation in two-phase downflow condensers can be calculated. Apply this method to your design problems, turn to **Page 147.**

☐ **Thermo Data for Petrochemicals, Part XXII . . .** This part covers the chloroethanes. These data are wrapped up in a neat bundle in one convenient article. You'll want this kind of information for future reference. Clip this one for your working file . . . **Page 155.**

☐ **Is Underground Storage Competitive? . . .** Cost of construction of both aboveground and underground storage are given directly from charts. Points of economic competition can be readily picked off. Here are data for rapid cost estimation. Turn to **Page 160.**

☐ **How to Predict Gravity Flow Rates . . .** This review of the published quantitative data, with developed equations, illustrates the use of the flow rate correlations. Problems associated with minimizing segregation and maintaining uniformity of downflow are discussed. Check your assumptions for dipleg and standpipe design with these charts and equations. Turn to **Page 162.**

☐ **Five Steps to Better Training . . .** Psychological studies have determined that concentration on five specific areas can markedly improve any training program. For a complete report on these training "boosters," plus a helpful chart of "do's and dont's" for training instructors, turn to **Page 223.**

☐ **How to Use Job Evaluation . . .** Contrary to popular belief, you do not need a consultant to set up an efficient job evaluation program. All you need to do is follow this step-by-step procedure as outlined by a well known industrial relations authority. Turn to **Page 225.**

☐ **How to Organize for Safety (Part 10) . . .** If you are planning to start a new safety effort or re-vamp an old one be sure to check the suggestions offered here by one of the nation's top safety authorities. You will find all the basic essentials you need to organize an effective safety program starting on **Page 237.**

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In '57 It's November

WE'VE BEEN KEEPING RATHER QUIET about our 1957 Petrochemical Handbook—quiet but real busy. But now's the time to start a talkin' because we don't want you or any of your friends to miss it. And in '57 it's going to be in the November issue.

Tom Ponder, PR's petrochemical editor, figures the Handbook will set a new record for size. The Refiner has never undertaken a special that caught on more quickly than the Petrochemical Special Issue, heretofore usually appearing in December, but this year scheduled for November.

This is our Fifth Annual Petrochemical Issue and our third Handbook. (In alternate years a supplementary issue called the Petrochemical Developments Issue is presented.) Anyhoo—

A new high as to content value also is confidently predicted. In addition to the important regulars that make up the backbone of the petrochemical industry we have some really outstanding newcomers. Approximately 90 processes, the flow charts in blueprint style, will be presented, each with a succinct but adequate description. It's a volume that every process man will want to hold onto; so in addition to being sure that your subscription has not lapsed, why not suggest to some of those easy grabbing friends of yours that now's the time to send in subscriptions of their own? Then they won't have to organize any raiding parties.

We're really anxious for the processing world to see what we have for them in our next month's issue!

Part of Their Job

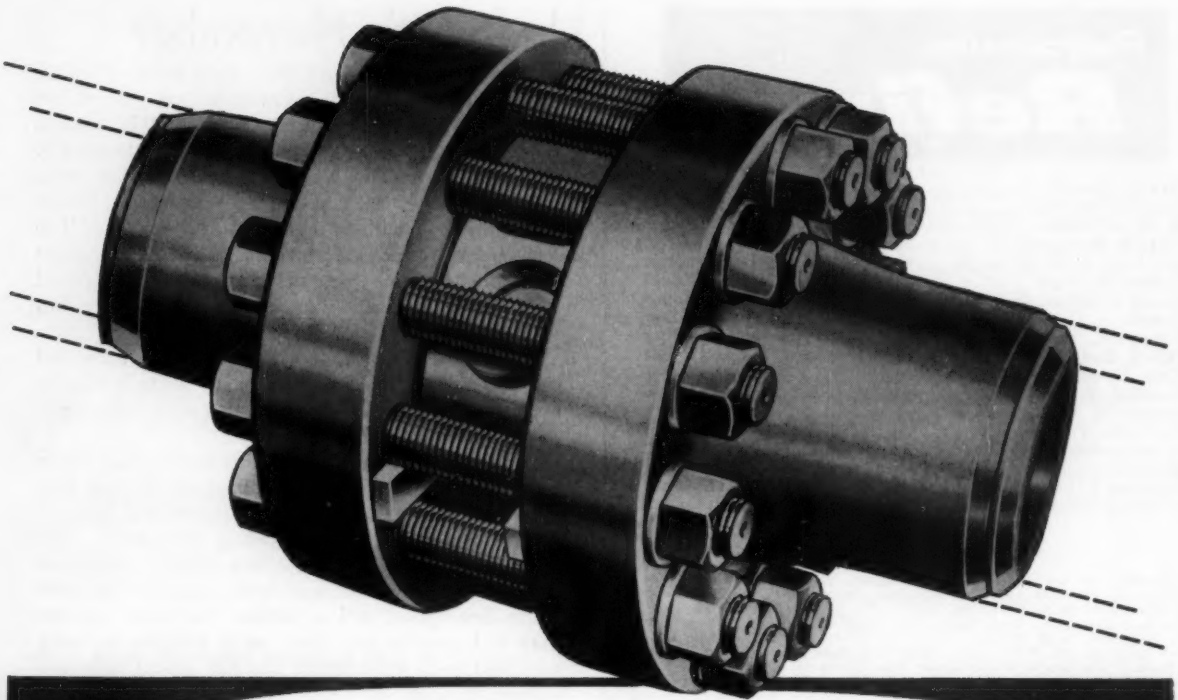
WE PROBABLY WON'T BE TELLING our own processing engineers anything new when we report that a recent survey of engineers by *Tide* revealed "that the reading of industrial advertising saves time and money for their companies simply because advertising speeds up the process of finding out about new products, materials and processes."

Tide had asked questions of "22 of the country's leading industrial engineers" and they were unanimous in this view.

Every one also agreed that technical engineering advertising gives them information about important products which is not available through general advertising. "Significantly," says *Tide*, "most of them think advertising should precede calls by salesmen."

As indicated, we're not surprised at these findings. Nearly every time our editors get with groups of engineers they sound them out on this matter and almost without fail the answer boils down to this: "Sure thing. I check PR's ads as closely as I do the editorial content." One or two have even told us that they read the ads first!

Item of Interest—Our Circulation Department recently told us something of interest that's worth repeating here: There are more PETROLEUM REFINER subscribers now in Japan than in any other country except the U. S. We had none there at the close of the war; so it's jumped from 0 to 835 in about 10 years!



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CHAPMAN 3-PIECE

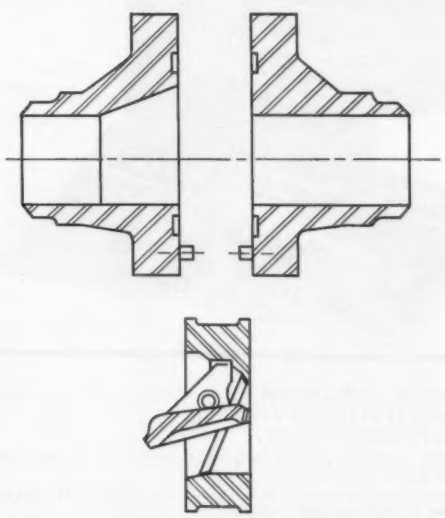
Tilting Disc Check Valve

When and if the time comes, it's as simple as this. You remove the studs between inlet and outlet section. You slip out the whole center . . . the working section . . . as a unit. You repair it or replace it and you have a valve as good as new in almost no time. It's the quickest, *lowest-cost* fix in valves.

Of course, with this 3-piece valve you get all the exclusive advantages of the Chapman 2-piece Tilting Disc Check Valve. You get fast, quiet operation. No flutter. No slamming. No banging. You get no scraping or wear and tear on disc or seat. You protect your whole valve system and keep your maintenance low.

If you don't have complete information on this and other Chapman Tilting Disc Check Valves, write for it, today. We'll get it into your hands, fast.

. . . just remove the center section



The Chapman Valve Manufacturing Co.

INDIAN ORCHARD, MASS.

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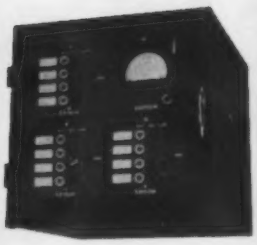
EDISON'S OMNIGUARD continuous temperature monitoring offers absolute dependability



Can be supplied for any type of annunciator or telemetry system

Edison has the answer to prohibitive pumping station and plant shutdown due to motor, generator or pump bearing failure. It's Edison's Omniguard, devised to detect and warn of excessive temperatures well in advance of danger points **with absolute dependability.** The use of Omniguard means the saving of thousands of dollars in downtime and maintenance man hours.

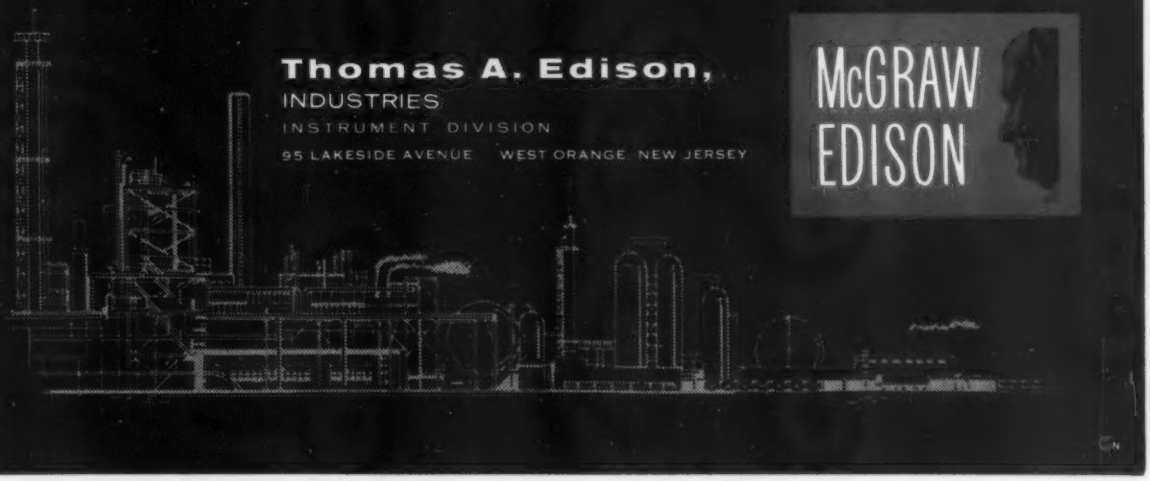
Here's how Omniguard works: easy-to-install resistance temperature detectors are inserted into the equipment to be monitored and are wired directly into the central control unit as one leg of a simple Wheatstone bridge circuit. No electronic circuits, moving parts, adjustments, or maintenance is involved in this fail safe instrument. As soon as a temperature rise occurs the mechanism is automatically shut off and an annunciator of any type (proximate or remote including telemetry) signals the warning.

Omniguard can monitor from four to four hundred points with the simple addition of building block units; each point is independently circuited so that Omniguard continues to monitor if other points are shut down. Critical temperatures exist everywhere in the petroleum industry — from remotely unattended pipeline stations to catalytic "crackers," where processes are in motion, or where machinery is in operation. Learn how Omniguard can save you money initially — costs less than any other system available — and thereafter — eliminates downtime, maintenance and manual inspection of equipment.

Write and tell us about your particular temperature monitoring problem.

SPECIFICATIONS:

Voltage:	115 volts, 60 cycles
Power drain:	25 VA maximum
Voltage error:	±2°F. maximum from 100 to 130 volts
External alarm:	1 per monitor. Contact rating 150 watts or 3 amp. non-inductive load



Thomas A. Edison,
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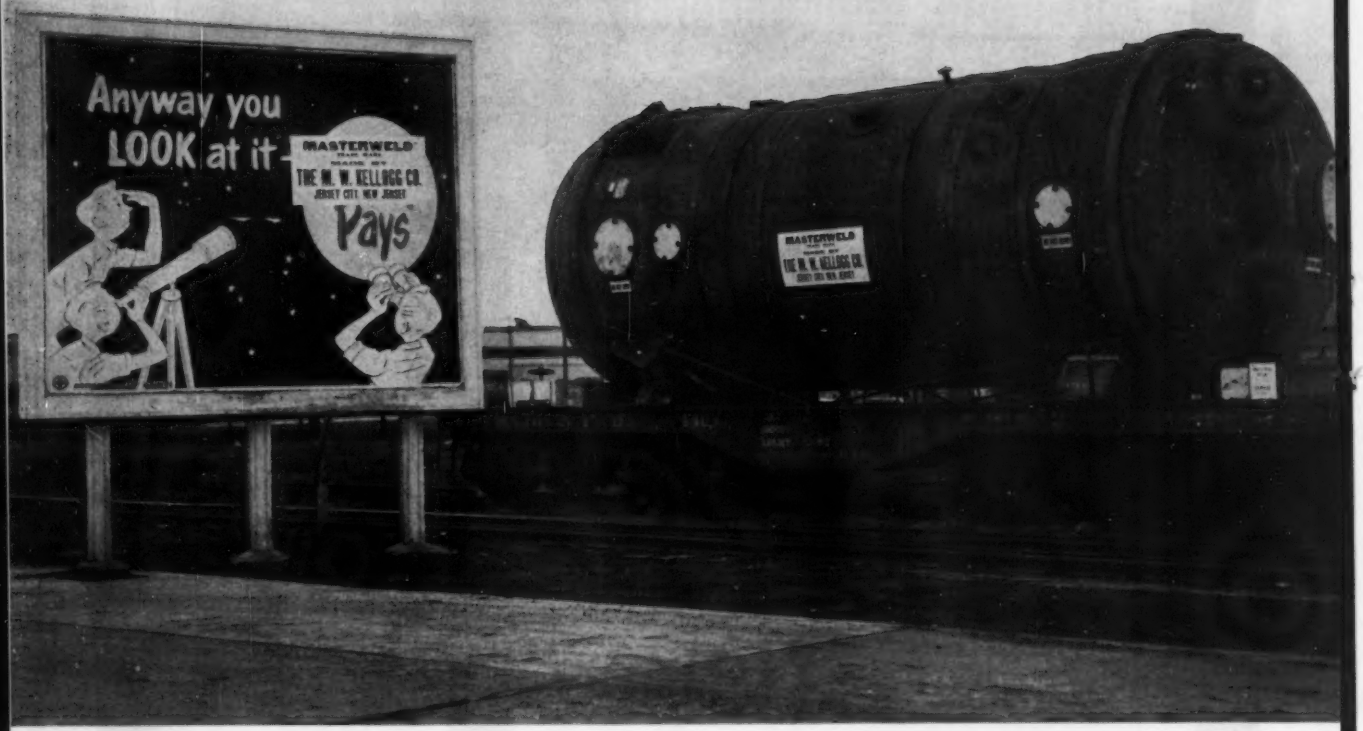
95 LAKESIDE AVENUE WEST ORANGE NEW JERSEY

McGRAW EDISON

Pride that Pays Off



Kellogg's plant people at Jersey City showed justifiable pride in their work when they modified this familiar sign in the company's railroad siding.* On its way to a major chemical company, the Masterweld unit is one of the largest heat exchangers ever built. Whether your heat transfer requirements need specially designed giants like this or standard type units, the personal pride of Kellogg's personnel in their designing, engineering, and fabrication pays off in longer and more satisfactory service for Kellogg's customers.

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THE M. W. KELLOGG COMPANY

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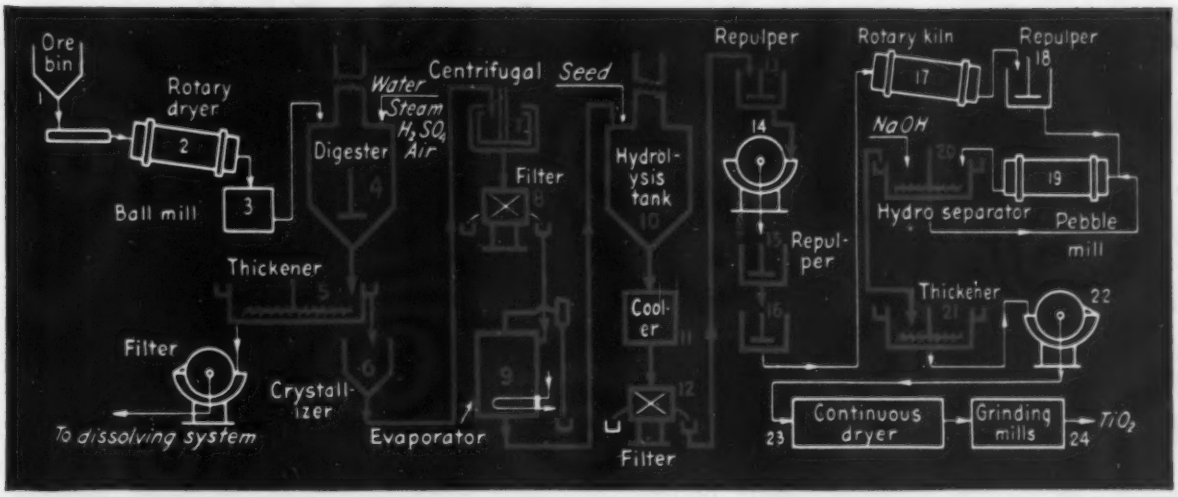


HOW *lead is used to control corrosion*

in Titanium Dioxide Production Equipment

TiO_2 is not corrosive. But H_2SO_4 is a real metal-eater . . . *first* on the attacking line in the production of TiO_2.

First on the defensive line, however, is *lead*, dependability itself when it comes to combating many corrosive chemicals.

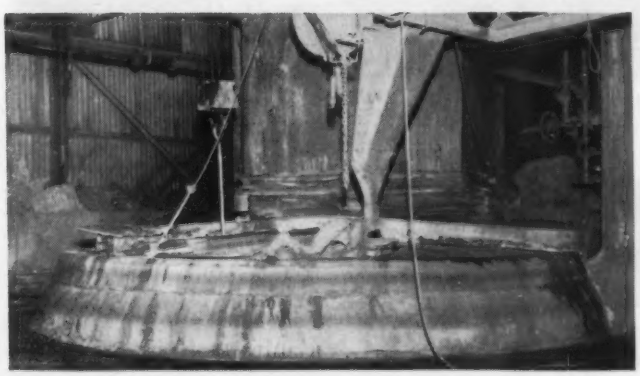
Lead reacts on contact with H_2SO_4 and other "corrosives" to form an insoluble, impermeable film. This film adheres to the metal surface . . . stopping or slowing down further reaction or attack.

Starting with digesters, where ilmenite ore is treated with sulphuric acid, *lead* is a steady defender . . . as lining for vessels and tanks, valves and pumps, in heating and cooling coils, in centrifugals and filters. It is used in combination with steel, concrete, wood or brick in many of the steps in the manufacture of TiO_2.

And bear this fact in mind: the use of *lead* cuts down-time. *Lead* lends itself to prompt, low-cost repairs. In case of leak or lesion, the affected area may be fixed quickly, with minimum loss of production. And . . .

. . . when you think of Lead . . .

think of National Lead



National Lead's long experience in bringing *lead* and steel together . . . in acid-handling lines, in complex, massive process, storage and shipping vessels . . . is at your service. When *lead* and steel are bonded together in this equipment, the union is stronger than *lead's* tensile strength. Cracking of the lining, due to vibration, pressure and rapid cyclic temperature changes, is held to a minimum. Creep is virtually eliminated.

Perhaps *lead* can save you money. Contact National Lead Company, Lead Lined Products, 111 Broadway, New York 6, N. Y., for information.

For more data on advertised products, use Readers' Service Cards, last page.

Buy the one tube steel with the longest tube life per dollar: *Ask the experts!*

THE Timken Company makes 22 different high-temperature tube steels to help you solve your heat, pressure, corrosion and oxidation problems. But only *one* analysis really fits your particular needs, gives you maximum tube life per dollar—your best life/cost ratio. To find this *one*, right analysis, *ask the experts!*

Timken Company metallurgists are recognized authorities on high-temperature steels. They have over 20 years of experience backing them up. They'll put this experience to work for you, study your specific requirements, recommend the *one* tube steel that fits them—most economically.

You can be sure, too, that the analysis of Timken® steel you get will have uniform high quality. Because the Timken Company makes its own fine alloy electric furnace steels, it can maintain rigid quality control from melt shop through final inspection.

Timken Company metallurgists will be glad to help you solve your tube steel problems. Ask the experts! The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

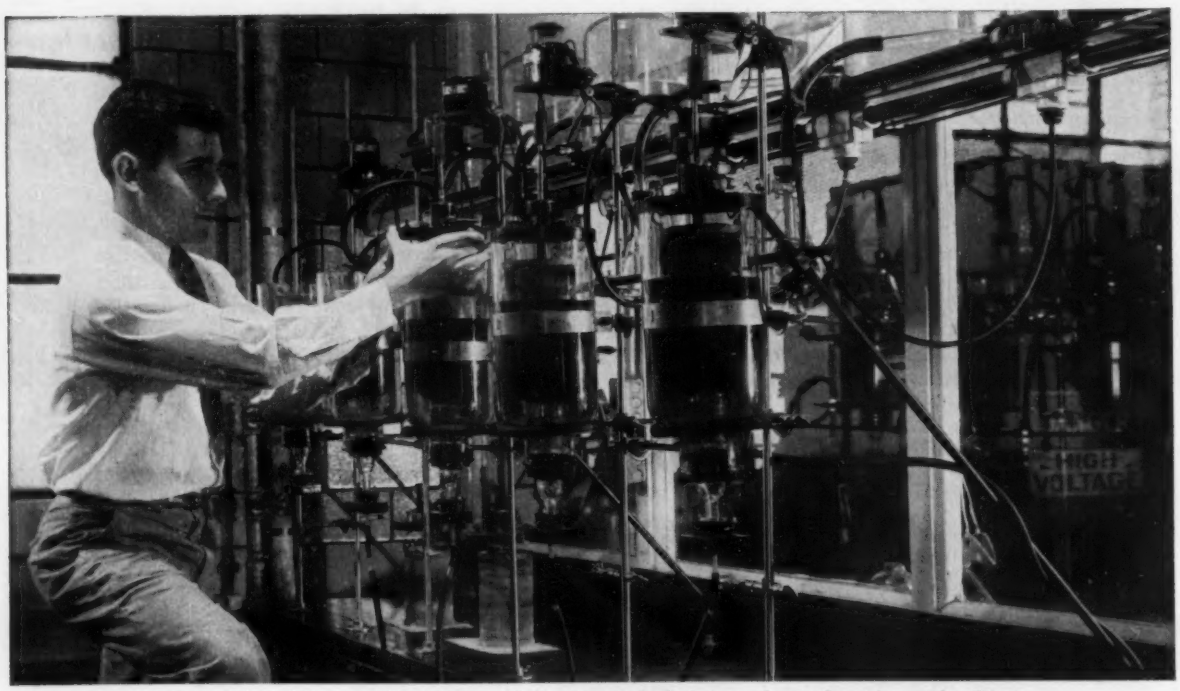
This month's report is on:

DM STEEL

Has unusually high creep strength for a pearlitic steel, good stability up to 1200°F., fairly good corrosion and oxidation resistance. Has 2 to 3 times the life of carbon steel where corrosion is not severe. Recommended for cracking furnace tubes, hot oil lines, superheater tubes, high temperature steam piping and forgings for accessory parts.

22 TIMKEN STEELS FOR HIGH TEMPERATURE SERVICE

Carbon	Sicromo 2	Sicromo 5S	18-8Ti
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	16-13-3
DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-20
Silmo	Sicromo 3	Sicromo 9M	25-12
DM	4-6% Cr.-Mo.	18-8 Stainless	
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti	18-8 Cb	



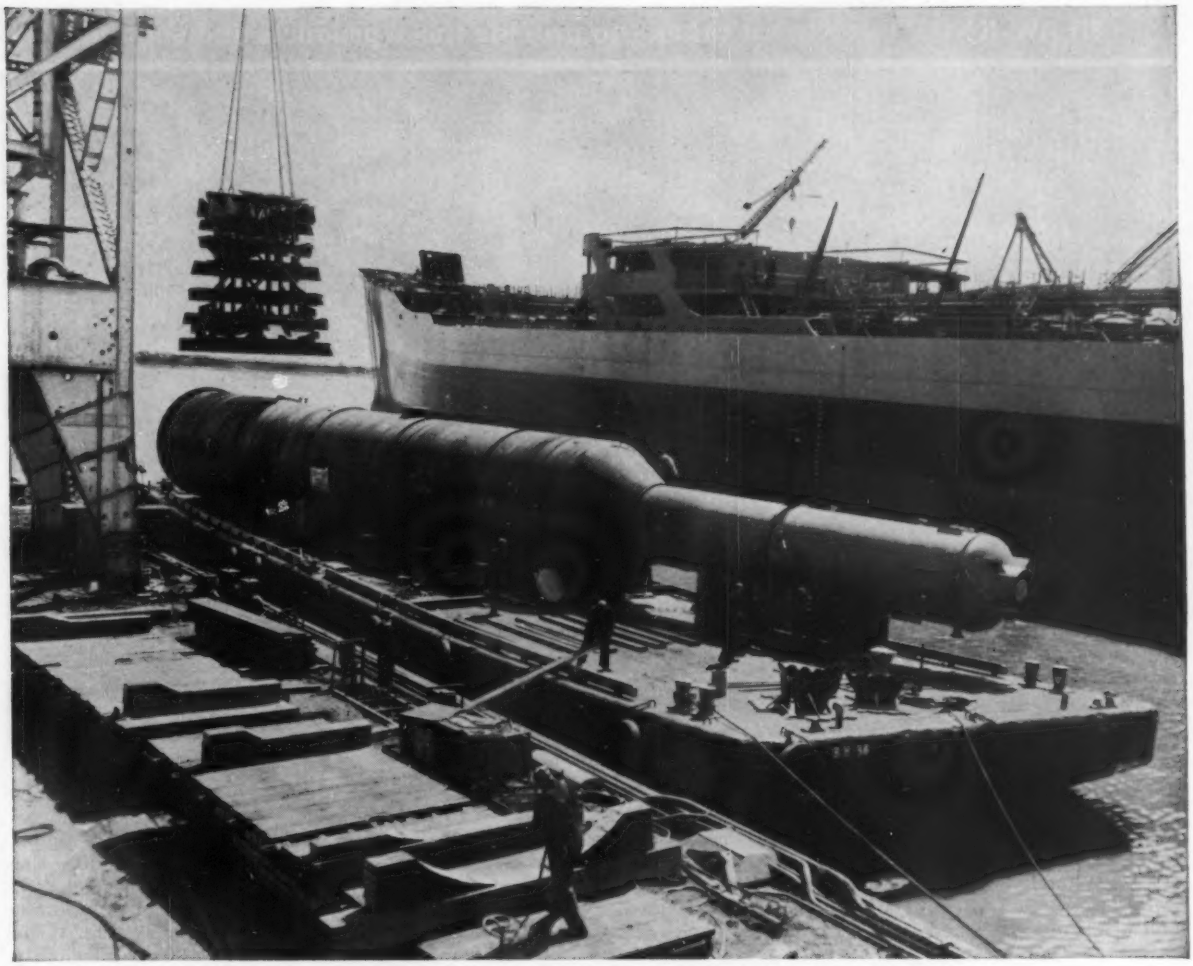
Special electrolytic extraction equipment helps separate inclusions, to give steel maximum cleanliness.

TIMKEN *Fine Alloy* STEEL

TRADE-MARK REG. U.S. PAT. OFF.

See the next Timken Televent hour, "The Innocent Years" over NBC-TV, Thursday night, November 21st.

For more data on advertised products, use Readers' Service Cards, last page.



standard procedure: VERSATILITY . . .

The variety of work which Sun Ship's integrated shops produce for use by industries on land and sea brings a matching variety of shipping problems.

Our facilities for tidewater shipment are used to economical advantage on many of the massive structures that go into the making of the nation's petroleum and chemical industries. The barge shipment of tower and shed row baffles, shown above, is a good example.

And of course—when shipment by land is necessary—Sun Ship rigging and routing find the ways and means to handle such items as large-diameter columns by rail and truck.

It's all a part of the versatility which forty years' experience has made part of "standard procedure" in service of its customers.

Our Sales Engineering Department would be glad to use its experience in helping you overcome any problem of construction or shipment that faces you. Write

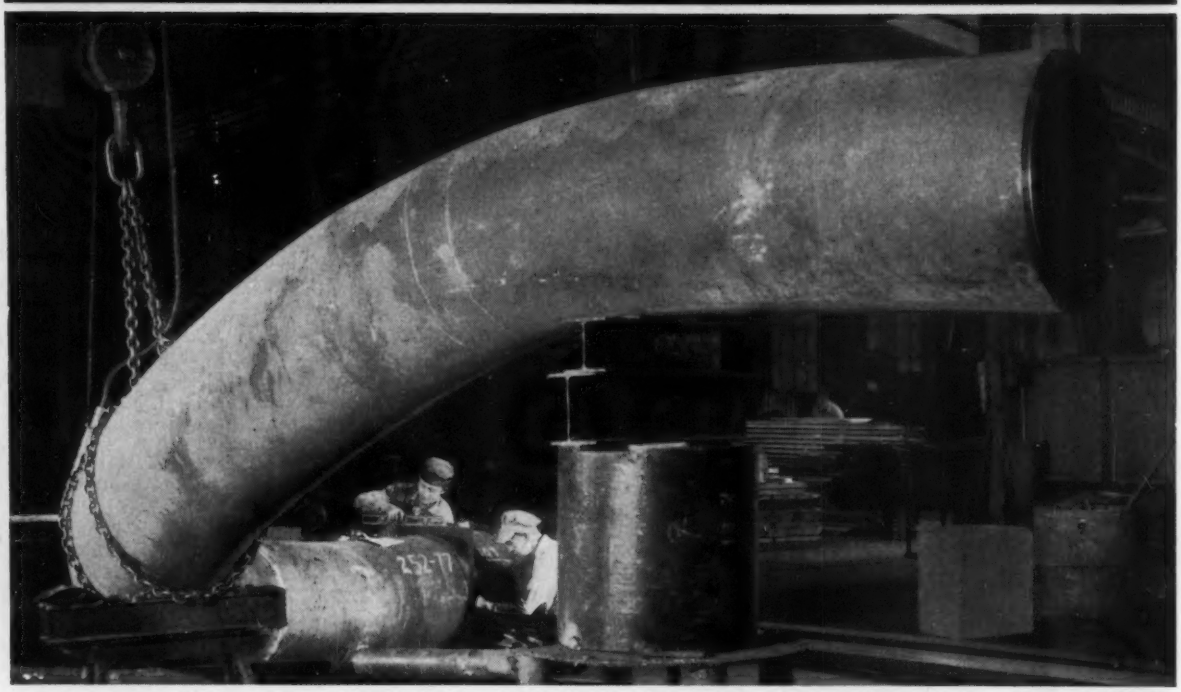
Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE (SINCE 1916) **CHESTER, PA.**

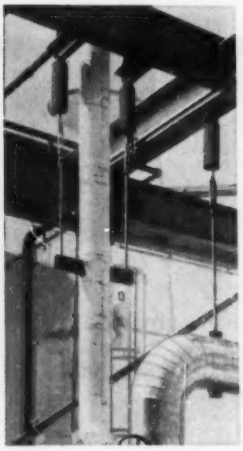
For more data on advertised products, use Readers' Service Cards, last page.

BLAW-KNOX has what it takes—to provide these products and services



Large chrome moly pipe being readied for shipment to new generating station. Making a right angle bend followed by a 24 degree, 18 foot bend in this heavy 27½ inch chrome moly pipe required all the skill and modern facilities of the Blaw-Knox power piping shop. Before shipment, piping is heat-treated and ultrasonically tested with a radar-type device for detection of any defects.

A new Blaw-Knox "6 x 6" Flexibility Matrix Method of computing stresses in power piping systems is now available to consulting engineers, companies, and individuals responsible for the design of power piping systems. By the use of an electronic computer this method cuts calculating time from months to a day; assures full accuracy to six significant figures; and has no limitations on the complexity of the system. Write for further information about our new "6 x 6" Flexibility Matrix Method.



Two-way control over movement of piping is provided by Blaw-Knox functional spring hangers with the patented internal swivel action—shown in this modern outdoor generating station. Our experienced engineers are available to both design and make recommendations for your hanger requirements. To get full information, write for Catalog No. 54.

Each year serious fire strikes one out of every seven manufacturing firms in this country. Be safe. Let a Blaw-Knox fire-protection engineer study your needs—and explain how you can pay for the system on our lease or deferred payment plan. To get more information send for Bulletin No. 2426—"Fire Can Destroy Your Business."

BLAW-KNOX

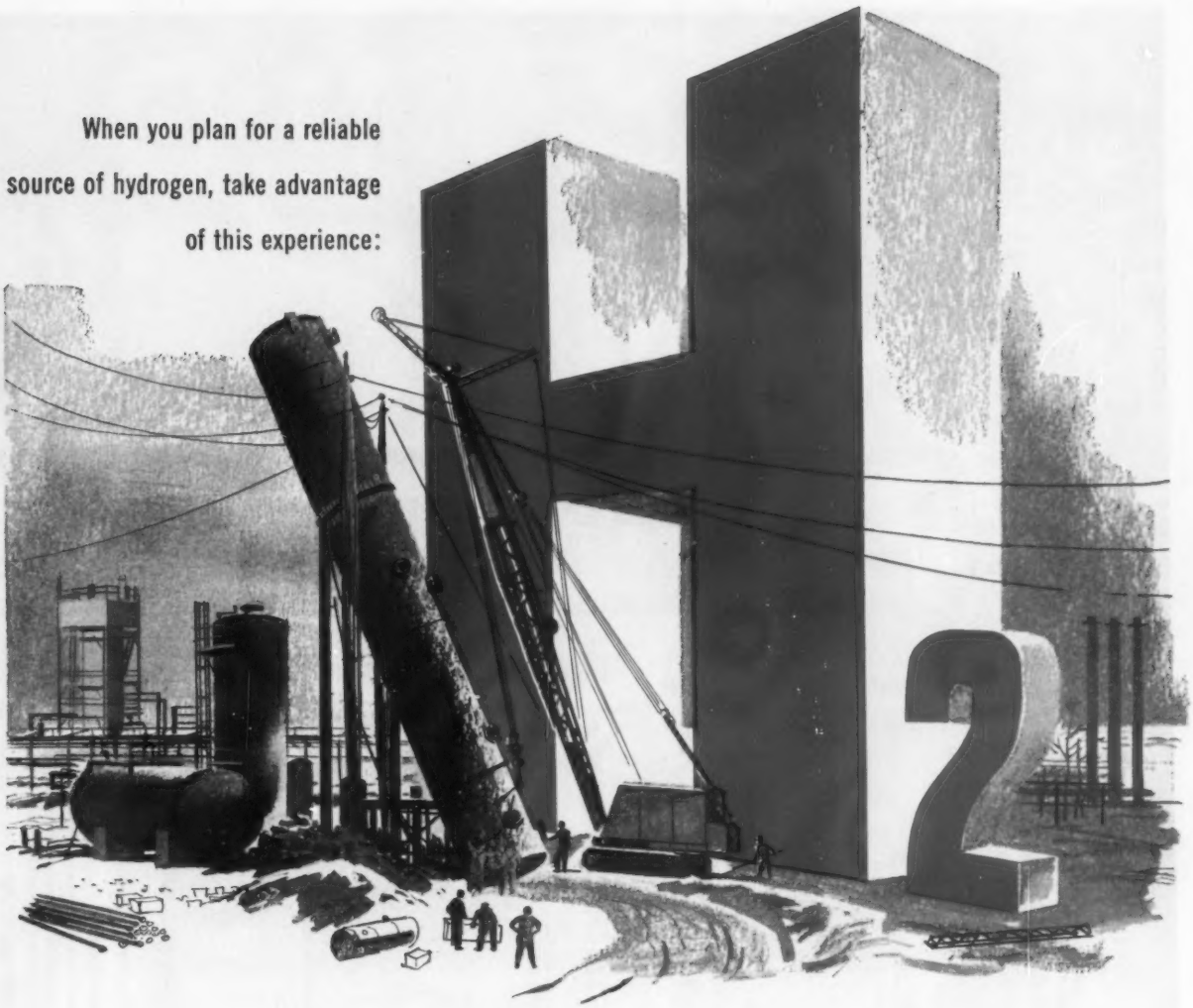
BLAW-KNOX COMPANY

Power Piping and Sprinkler Division

829 Beaver Avenue • Pittsburgh 33, Pennsylvania

Complete facilities for prefabrication and erection of piping systems for all pressures and temperatures ... complete line of standard and custom-engineered pipe hangers, supports and vibration eliminators ... complete line of automatic sprinkler systems for standard and special hazards

When you plan for a reliable source of hydrogen, take advantage of this experience:



More than 50 hydrogen plants have been built by Girdler

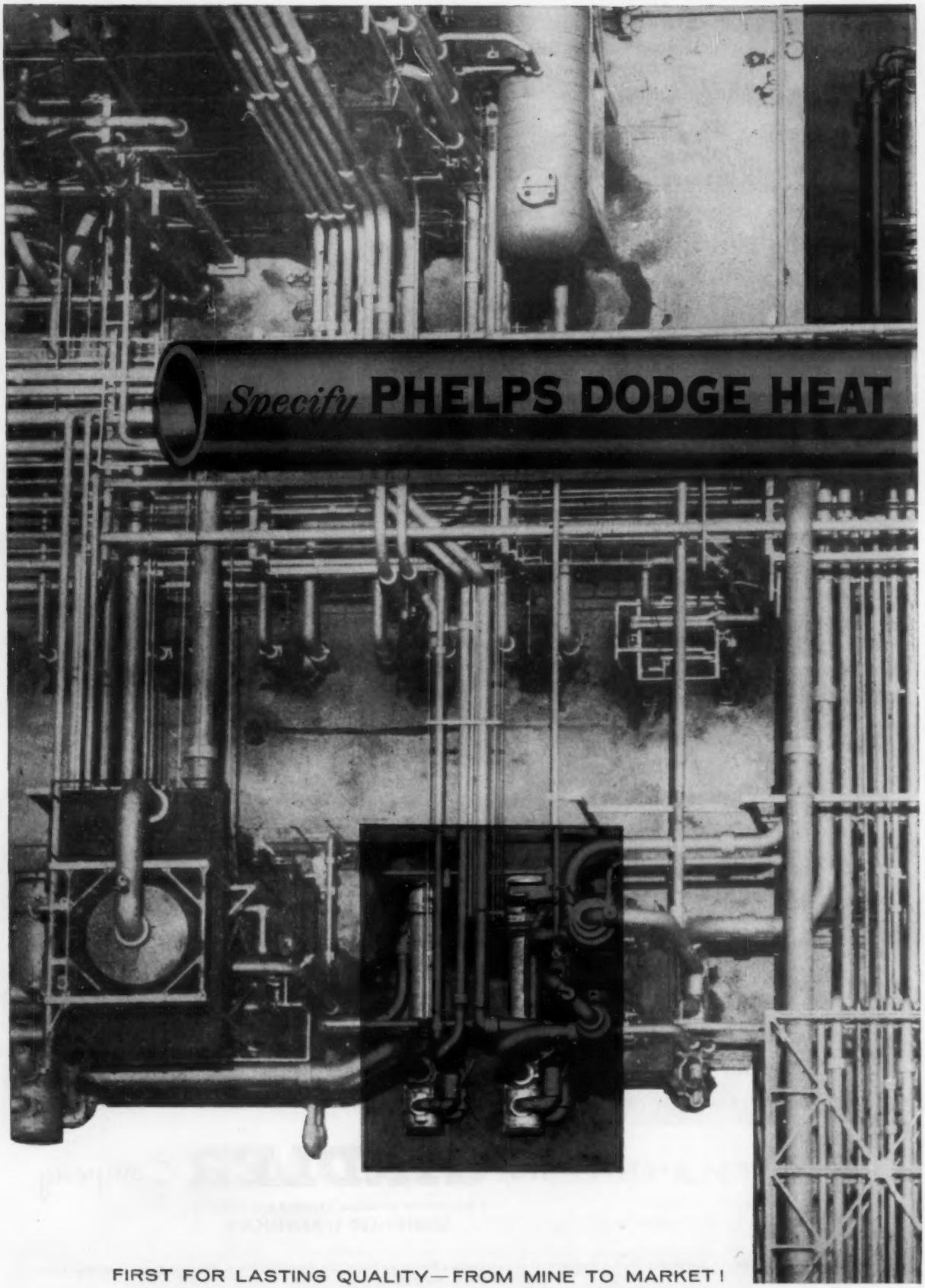
In your search for *experienced* engineer-constructors to provide dependable hydrogen facilities, let these facts guide you: Girdler has built most of America's hydrogen plant capacity installed during the past ten years. Big and small . . . for low-purity or for high-purity hydrogen . . . these plants provide undisputed evidence of Girdler's know-how and ability. Call or write us for complete information.

The **GIRDLER** Company

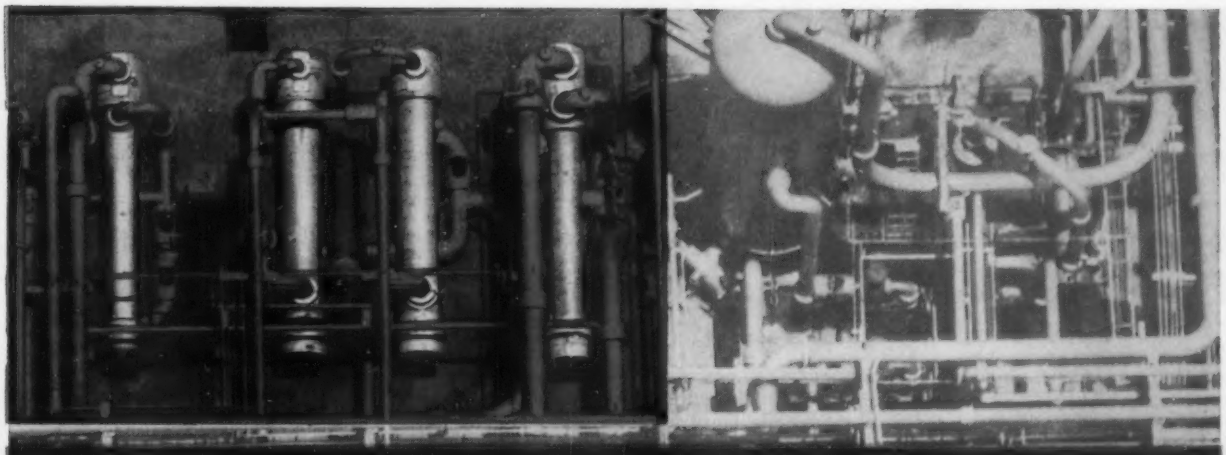
A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION . . . Design, Engineering, Construction of Hydrocarbon Processing Plants, Gas Producing Plants, Chemical Plants, Specialty Catalysts
Offices: New York, San Francisco

For more data on advertised products, use Readers' Service Cards, last page.

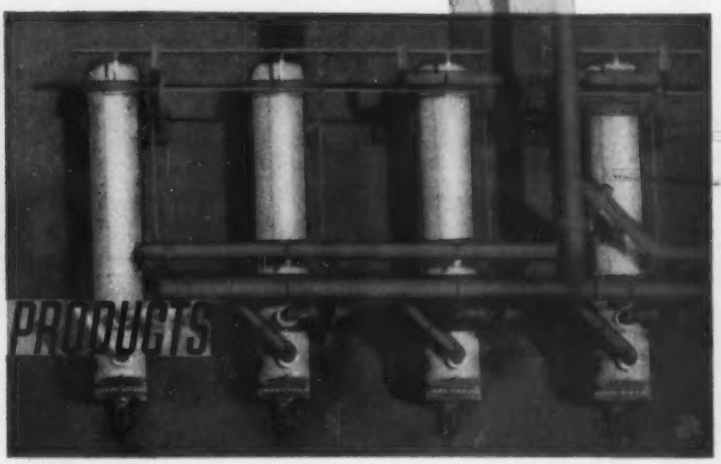


FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!



EXCHANGER TUBES *for Longer Service!*

- Full range of copper-base alloys for every application.
- Vast background of application engineering to assist in proper alloy selection.
- Complete control of quality throughout every step of manufacture.



PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

you can meet any lubrication specification if you

BLEND WITH ENJAY PARATONE®

(VISCOSITY-INDEX IMPROVERS)

Base stocks blended with Enjay Paratone can be compounded into lubricants combining cold-weather quick starting properties with high temperature, low consumption characteristics. These lubricants are *all-season* oils, featuring improved gas mileage. More and more refiners and blenders are relying exclusively on Paratone to produce the high "VI" required in these all-season oils.

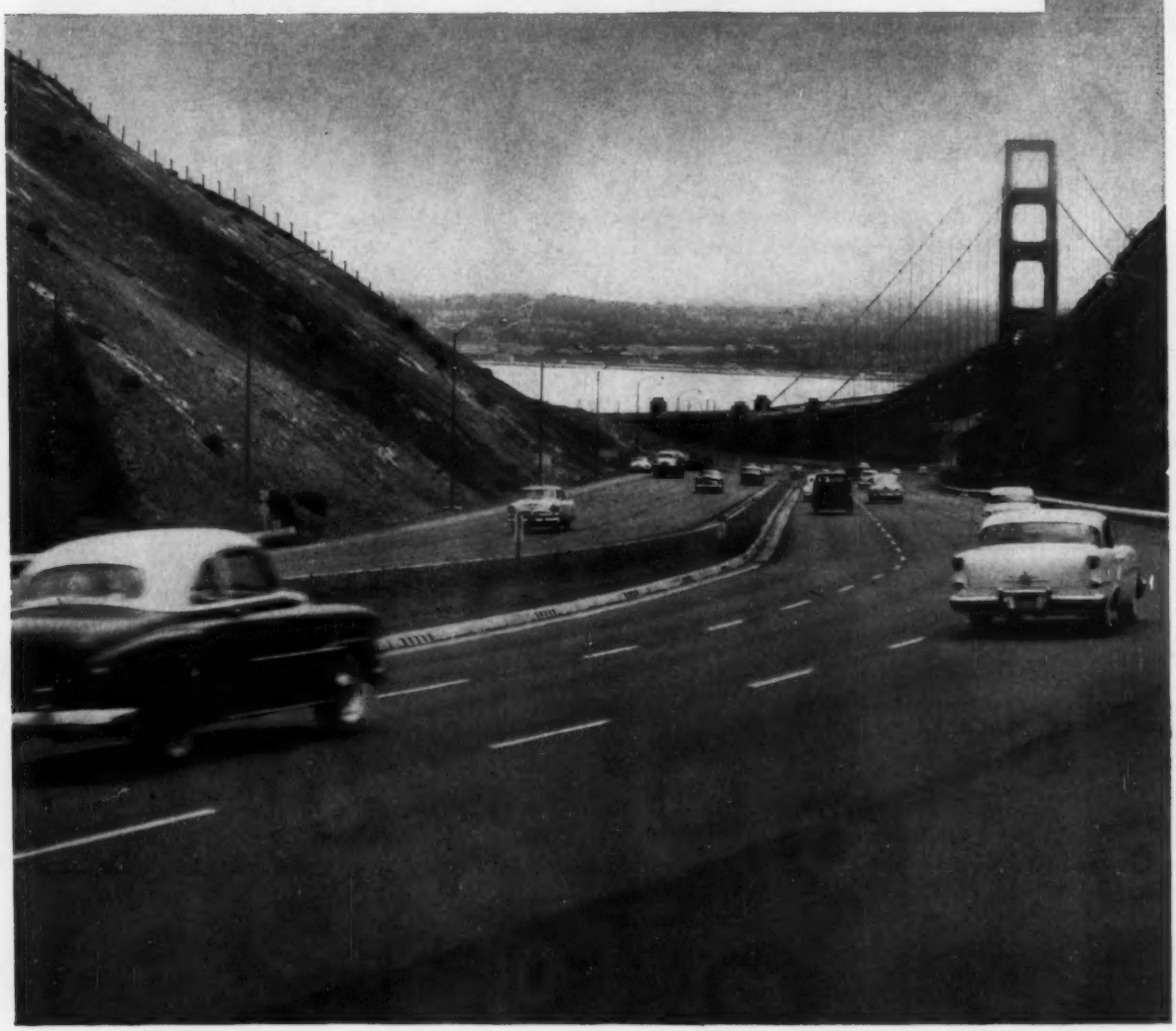
Through years of intensive research and development work with automotive manufacturers, Enjay has developed the only *complete line* of high quality additives (Paramins®) that can assure *maximum* performance characteristics. Why not let this experience and know-how work for *you*? Write, wire or phone the Enjay Company.

ENJAY

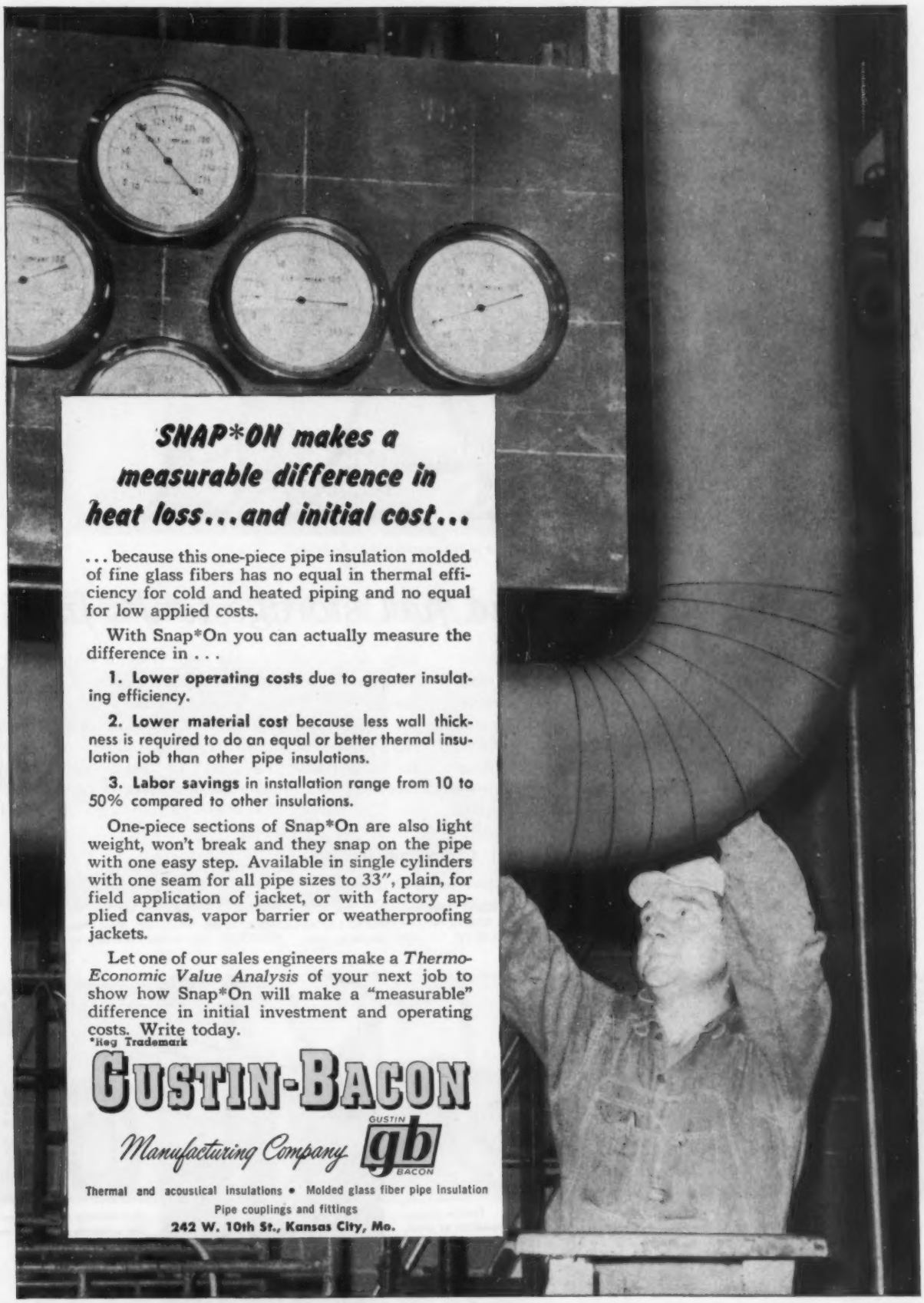
Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st ST., NEW YORK 19, N. Y.

Akron • Boston • Chicago • Detroit • Los Angeles • New Orleans • Tulsa



For more data on advertised products, use Readers' Service Cards, last page.



*SNAP*ON makes a measurable difference in heat loss...and initial cost...*

... because this one-piece pipe insulation molded of fine glass fibers has no equal in thermal efficiency for cold and heated piping and no equal for low applied costs.

With Snap*On you can actually measure the difference in . . .

1. **Lower operating costs** due to greater insulating efficiency.

2. **Lower material cost** because less wall thickness is required to do an equal or better thermal insulation job than other pipe insulations.

3. **Labor savings** in installation range from 10 to 50% compared to other insulations.

One-piece sections of Snap*On are also light weight, won't break and they snap on the pipe with one easy step. Available in single cylinders with one seam for all pipe sizes to 33", plain, for field application of jacket, or with factory applied canvas, vapor barrier or weatherproofing jackets.

Let one of our sales engineers make a *Thermo-Economic Value Analysis* of your next job to show how Snap*On will make a "measurable" difference in initial investment and operating costs. Write today.

*Reg Trademark

GUSTIN-BACON

Manufacturing Company GUSTIN gb BACON

Thermal and acoustical insulations • Molded glass fiber pipe insulation
Pipe couplings and fittings

242 W. 10th St., Kansas City, Mo.

For more data on advertised products, use Readers' Service Cards, last page.

by PDM — PITTSBURGH · DES MOINES STEEL CO. — ENGINEERS · FABRICATORS · CONTRACTORS

for our air bases in

SPAIN

79 *underground fuel storage tanks from*

A good example of Pittsburgh-Des Moines' capacity to serve the customer dependably under the most exacting conditions is provided by this project recently completed for the United States Air Force in Spain. Starting from scratch, a complete fabricating plant was set up at Cadiz, an organization established (including a welders' school for API certification in 4 positions), and new methods of construction developed employing large sub-assemblies in the field. Working with Spanish labor, a rough winter with the worst rains in 50 years, and with soil conditions ranging from sand to rock, the job was done on schedule. • In America, we meet your storage tank needs with complete fabricating plants in Pennsylvania, Iowa and California—skilled field erection forces—responsible guarantee of satisfaction.

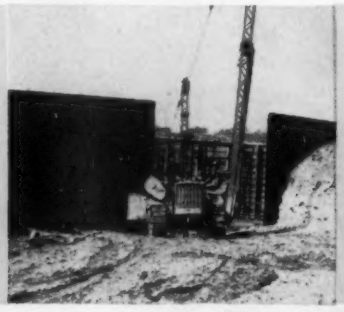
Write, phone or wire for consultation.

Pittsburgh-Des Moines Steel Company

Plants at: PITTSBURGH, DES MOINES, SANTA CLARA, FRESNO, and CADIZ, SPAIN

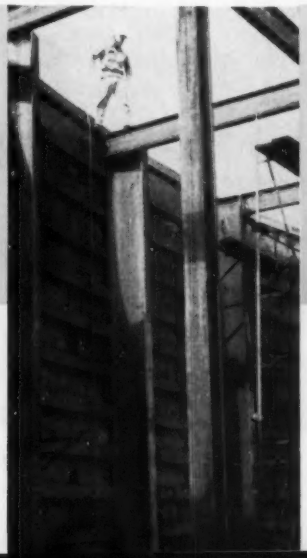
Sales Offices at:
PITTSBURGH (25)----3482 Neville Island
NEWARK (2)---1763 Military Park Bldg.
CHICAGO (3), 686 First National Bank Bldg.
EL MONTE, CAL.-------P. O. Box 2012
DES MOINES (8)------983 Tuttle Street
DALLAS (1)------1287 Praetorian Bldg.
SEATTLE (1)----Suite 590, 500 Wall St.
SANTA CLARA, CAL.---689 Alviso Road
DENVER (2)--323 Railway Exchange Bldg.

Sub-assemblies in place, forming tank wall.



Tractor cranes speed handling of steel.

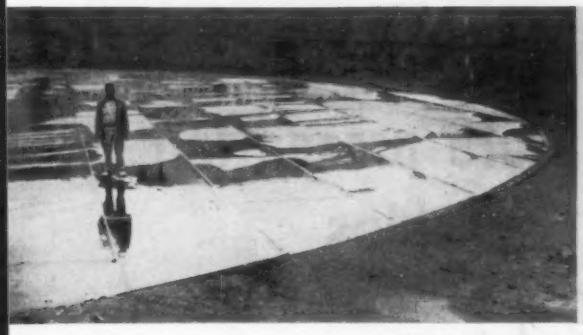
Detail of interior bracing and roof supports.



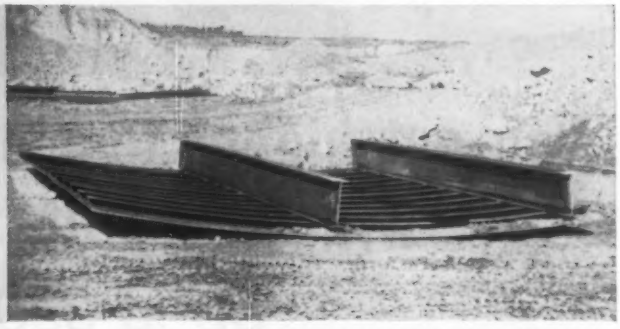
Reinforcing steel in place for concrete slab over tank roof.

Typical liquid fuel storage unit at completion, ready for earth cover.

7,500 *to* 80,000 *barrels in capacity*



Foundation and bottom plates in place.

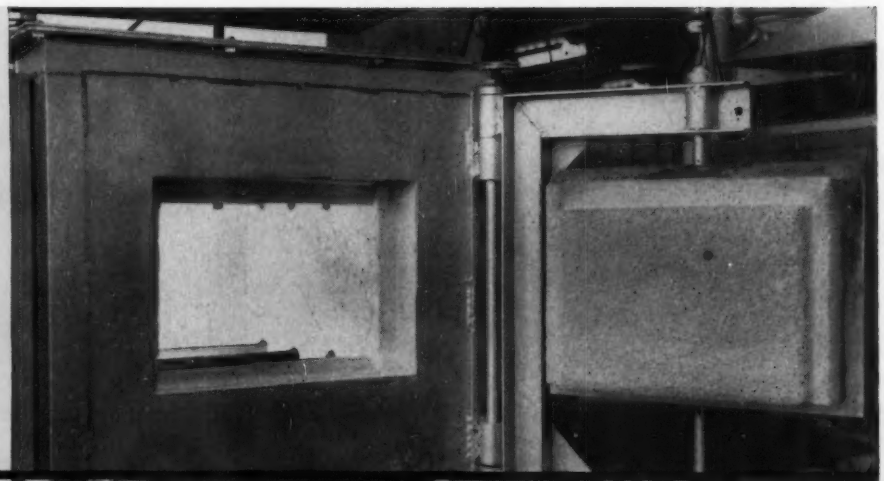


Sub-assembly, made with field jigs. Plates reinforced with shop-welded T's.

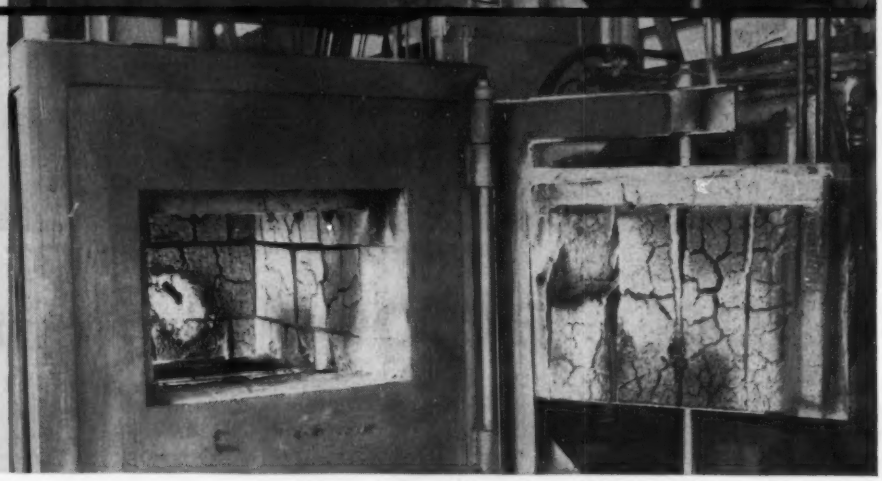
Pouring concrete over roof, from buggy platforms.

Backfilling around tank and placing earth fill over roof.

PITTSBURGH-DES MOINES STEEL CO.



LINED WITH ALUNDUM 33-I CASTABLE, this furnace has been used for almost a year as a periodic furnace for high-temperature laboratory test work. During this time the door was opened and closed over a thousand times with the furnace at temperature. Even after this rugged service, the ALUNDUM Castable lining shows hardly any signs of wear.



LINED WITH A COMPETITIVE HIGH GRADE INSULATING BRICK, this similar furnace was used in the same service for an equal length of time. Under equally severe thermal shock conditions the lining cracked and spalled and this furnace must be rebuilt.

You get higher temperature protection with ALUNDUM* castables

Up to 3300° F!

ALUNDUM 33-I Insulating Castable is made up primarily of countless tiny, pure aluminum oxide bubbles. Forming a network of air spaces it provides excellent insulation, even at the highest commercial temperatures.

ALUNDUM 33-HD Heavy Duty Castable is chiefly composed of dense grains of pure aluminum oxide. It is recommended for forming dense monolithic surfaces in constructing many types of furnaces where high temperature conditions are more severe.

Both ALUNDUM 33-I and 33-HD Castables protect at temperatures up to 3300° F and are very easy to mix and use. You can cast simple or complex shapes with them quickly and inexpensively for many installations and replace more expensive pre-fired shapes.

See your Norton Representative for more facts on how these new Castables can provide long, trouble-free service that saves you time and money. Ask him for the folder *Two New Norton Castables*, or write for your free copy to NORTON COMPANY, Refractories Division, 470 New Bond Street, Worcester 6, Mass.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

NORTON

REFRACTORIES

Engineered... Rx ...Prescribed

Making better products... to make your products better

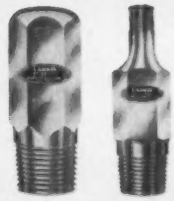
NORTON PRODUCTS:
Refractories • Abrasives
Grinding Wheels • Grinding Machines
BEHR-MANNING DIVISION PRODUCTS:
Coated Abrasives • Sharpening Stones
Behr-cat Tapes

For more data on advertised products, use Readers' Service Cards, last page.

THE NAME THAT MEANS QUALITY FITTINGS

In drilling, production, or refinery applications, Larkin quality fittings are installed with confidence. The many separate manufacturing and inspection phases are your guarantee that every Larkin fitting is built to exacting standards. Manufacturing know-how and years of experience means that **you get what you pay for** in Larkin fittings.

All Larkin products are available through your supply store.



Larkin Hexagonal Bull Plug

Larkin Hexagonal Swaged Nipple

Color coded for thread identification

Larkin Forged Steel Swaged Nipples

LARKIN PACKER COMPANY, INC.

WAXAHACHIE, TEXAS

LARKIN
...Through Your Supply Store

PESA

LARKIN LEADERSHIP HAS BEEN EARNED BY YEARS OF DEPENDABLE PERFORMANCE

Keep areas weed-free . . . avoid fire hazards

Spray Du Pont TELVAR® WEED KILLERS just once for season-long weed control

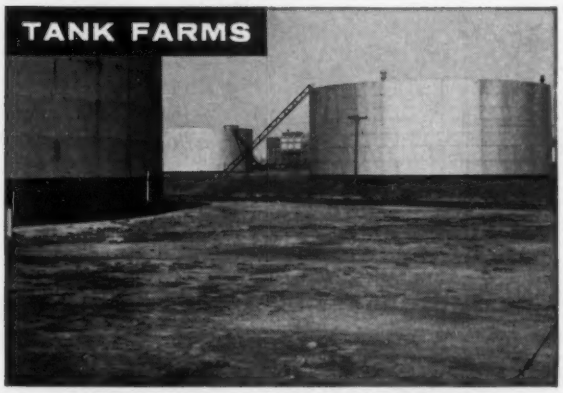
You can eliminate weeds and grasses that create fire hazards and that make maintenance difficult and costly. Just one spray of Du Pont "Telvar" controls weeds for a season or longer. "Telvar" kills weeds through the roots, then remains in the soil to provide residual action long after the initial spray is applied. Low dosages save you cost, handling and storage space. "Telvar" weed killers are non-corrosive to equipment, non-volatile, low in toxicity to humans and animals. For low-cost, long-term control of weeds, include "Telvar" in your maintenance program.

TELVAR®
Monuron and Diuron
WEED KILLERS

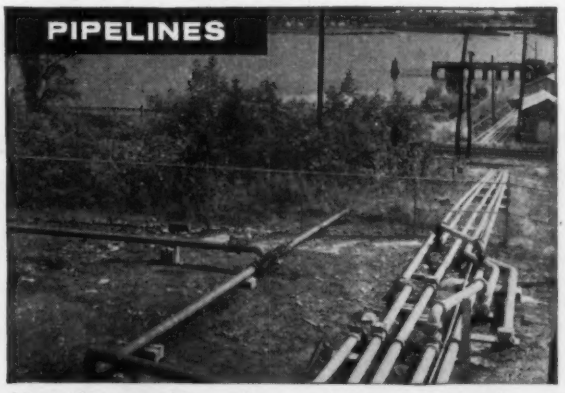
DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Note the excellent control of weeds and grasses around this wellhead from just one application of "Telvar."



The treated area around this tank farm has remained weed-free for an entire season.



Along these pipelines, where maintenance is tough, one application of "Telvar" has kept the treated area weed-free for a year.

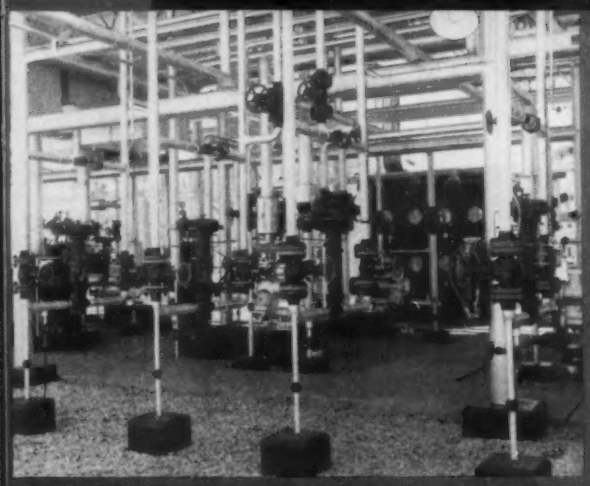
On all chemicals, follow label instructions and warnings carefully.

For more data on advertised products, use Readers' Service Cards, last page.

stop

product contamination before it begins

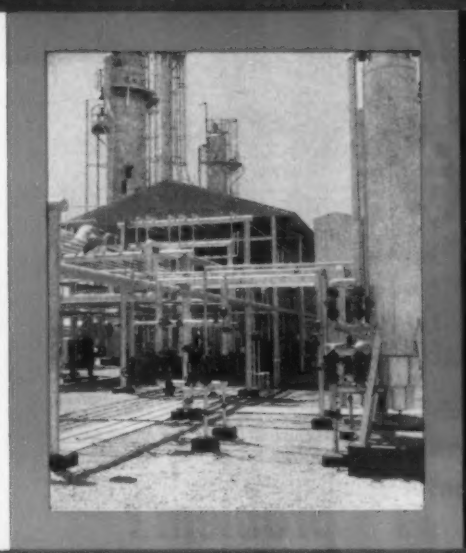
by using orbit forged steel asa class valves

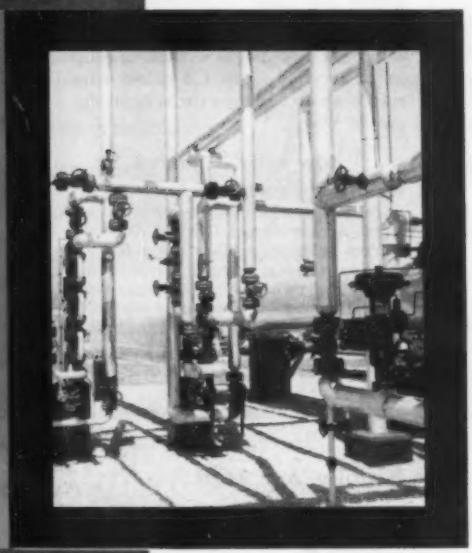


LEFT
AT A KANSAS GASOLINE PLANT:
In foreground, depropanizer and debutanizer, reflux accumulator pressure relief and level control valves. Reflux pumps in background.

orbit's money-saving features are

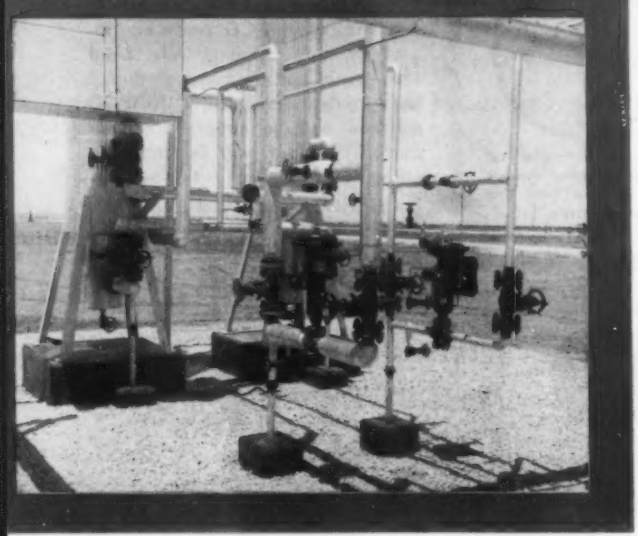
1. non-lubricated seating
2. low maintenance
3. vapor-proof forged steel body and bonnet
4. easy operation
5. positive closure





ABOVE
Left to right, de-ethanizer feed, bottoms exchanger, and liquid level control valve.

LEFT ABOVE
Propane dehydrators in right foreground. In background, plant process pump area.



LEFT
Propane dehydrators

ORBIT ASA CLASS VALVES are available in Carbon or Stainless Trim. Full Round Opening Sizes 1" thru 4". Ratings: 300 lbs. thru 2500 lbs. Flanged or Screw Ends. Venturi Opening Sizes 2" thru 6". Ratings: 150 lbs. thru 2500 lbs. Flanged End Only.

Available thru your favorite oil field supply store or refinery supply house.

ORBIT VALVES®

ORBIT VALVE COMPANY
BOX 699, LUther 4-4761, TWX TU 925 TULSA, OKLAHOMA

WAREHOUSES: HOUSTON, TEXAS, 407 Velasco, CApitol 8-6623, TWX HO 115; ODESSA, TEXAS, 402 West County Road, FEderal 7-2263, TWX ODESSA TEX 8041; EDMONTON, ALBERTA, CANADA, 7119-104th Street, Phone 391-283

WEST COAST REPRESENTATIVE: Fred P. Koenig Company, Long Beach, Calif., 3815 Atlantic Avenue, GArfield 4-3834

CANADIAN REPRESENTATIVE: T. R. Pickford & Company, Ltd., Calgary, Alberta, 536 8th Avenue West, Phone 2-7371

EXPORT REPRESENTATIVE: New York 36, N. Y., 500 Fifth Avenue, BRyant 9-2236

Now! Enter against pressure safely... *at any time!*

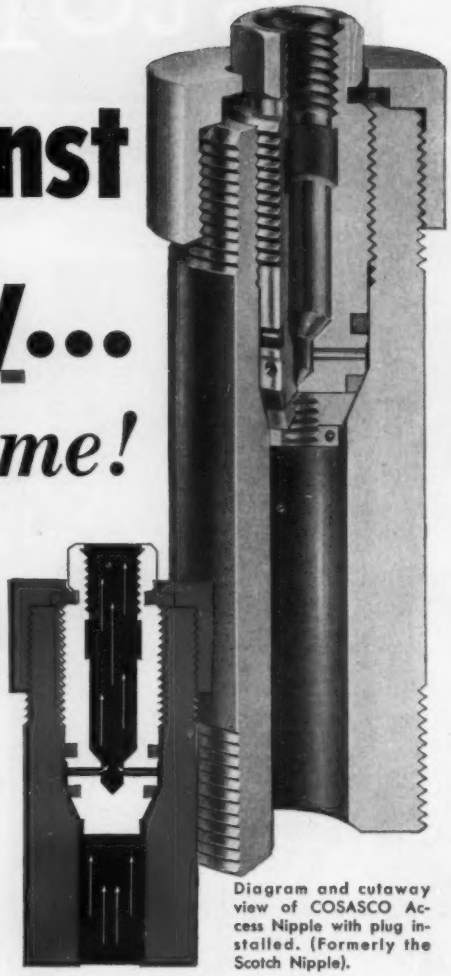


Diagram and cutaway view of COSASCO Access Nipple with plug installed. (Formerly the Scotch Nipple).

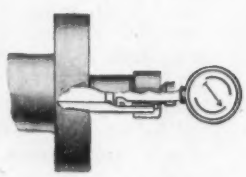
Wherever COSASCO Access Nipples are installed, you can go in against pressure with ease and perfect safety. At well heads, either the production string or annulus can be entered for instrument work. At refineries or along pipe lines, samplers, thermocouples, hydrogen probes, or coupons for corrosion studies can be inserted *without interfering with operations!* And expensive valves or other externals can be replaced or removed at will and without loss of pressure or product.

The COSASCO Access Nipple has a removable low carbon grade 303-304 stainless steel plug which, when turned down on the fine threads in the nipple outlet, effectively seals off the nipple at a tapered seat below. By-pass holes in the plug wall, between primary and secondary seals, provide communication through the plug to the exterior when the plug is backed out against a safety ring run down on the pipe threads on the nipple body.

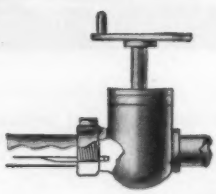
How entry is gained

With the COSASCO Retriever (Lubricator) and a full-opening valve mounted on the Access Nipple, COSASCO plugs, coupon holders or other units for inspection, testing, sampling, can be installed and removed at will regardless of pressure and without equipment shutdown. Details will be supplied promptly, on request.

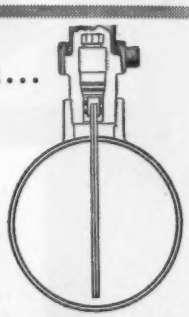
How **COSASCO** *Access* Nipples are used...



As a gauge valve, with plug installed. Gauge screws into end of plug.



As a valve re-installation nipple, with a thread and seat protector replacing the plug.



As a coupon holder for corrosion studies through taps in pipe lines and pressured vessels.

Protect equipment . . . Save product

What's your problem?

If it's an entry-against-pressure problem, COSASCO engineers invite you to submit details. Send blue prints and drawings to depict the problem, and the COSASCO solution will be supplied *without charge*. And you will be under no obligation whatever for this service.

COSASCO Access Nipples are applicable to any pressure or storage system, hydraulic or gaseous.

COSASCO

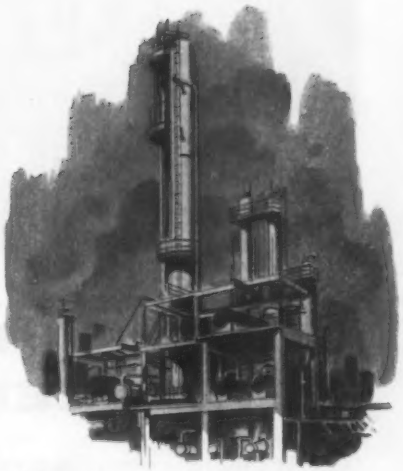
Division of Perfect Circle Corporation

11655 McBean Drive, El Monte, California • Export Office: 3631 Atlantic Avenue, Long Beach 7, California

Economy is TRADITIONAL at WESTERN

Economy is important in COKING

Economy in operation and maintenance is *designed* into Western Heat Exchangers, from drawing board to final fabrication. The production of trouble-free, long-service heat exchangers is of utmost importance for any process application.



Economy is also important in the coking process for producing clean gas oils which are suitable for catalytic cracking. Thus, the design of the furnace is such that a minimum of coke is laid down within the furnace coils; the coke drums usually being operated on a 48-hour cycle, with each drum given 24 hours on-stream, requiring only one dumping crew.

True economy eliminates waste and demands equipment of better quality, designed for longer on-stream time and reduced maintenance. Whatever your process requires in heat exchangers, let Western heat transfer equipment provide economy and greater profits for you.

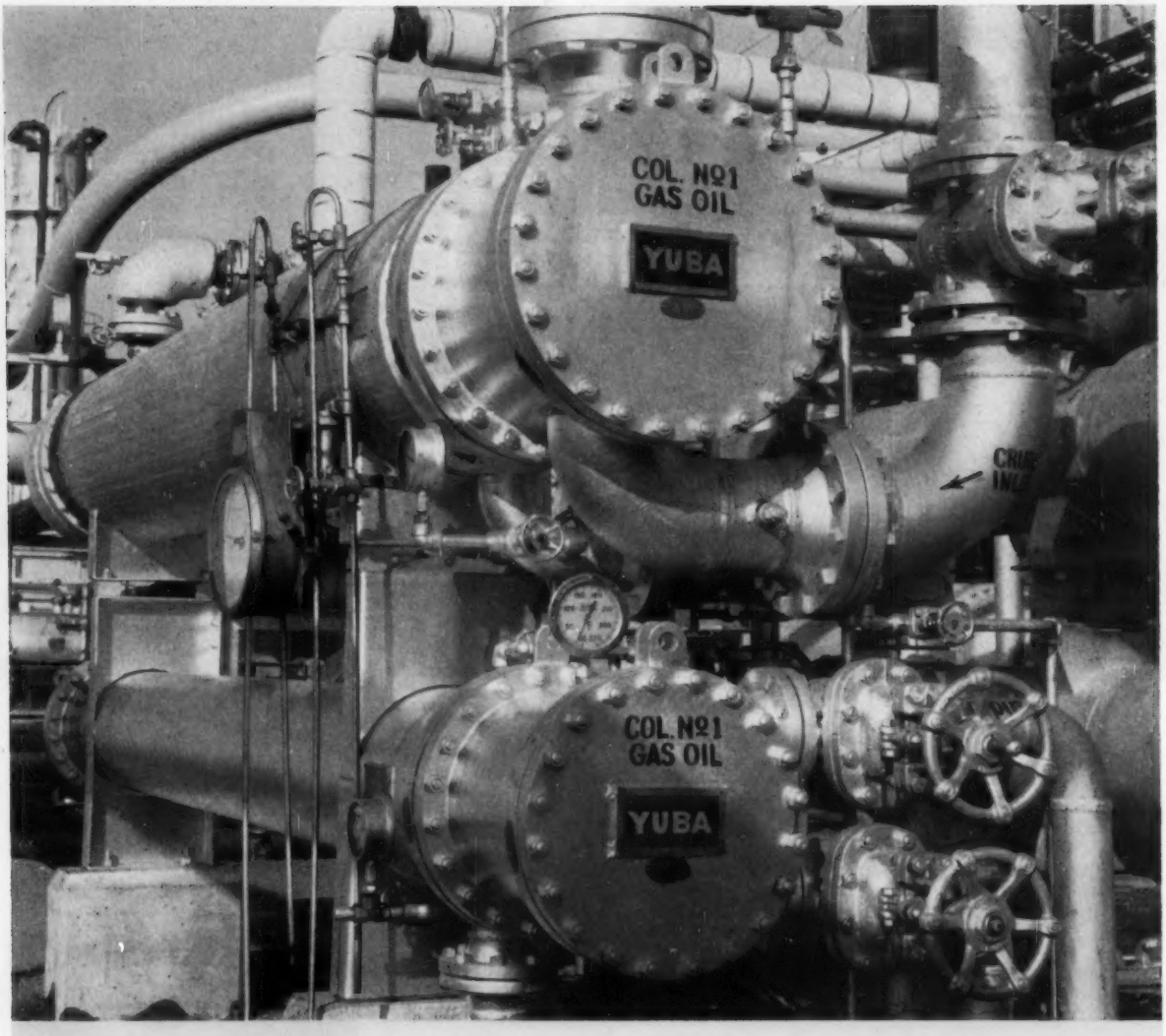
Western sales-engineering representatives await your call.

WESTERN

HEAT EXCHANGERS

WESTERN SUPPLY COMPANY

P.O. Box 1888 – Tulsa, Oklahoma



WHAT YUBA MEANS BY ENGINEERED HEAT EXCHANGERS

The manufacturer of heat exchangers is the sales engineer who services your account... the design engineer who designs the equipment and selects the materials... the welding engineer who specifies the welding procedures... the quality control engineer who sees that incoming materials meet specifications . . . that top-quality work is performed at every stage of manufacture... and the production control engineer who schedules your order so it will arrive the day you need it.

These competent people are to be found at YUBA's plants, in both the East and the West, where heat exchangers are made. Call YUBA for creative engineering and precision manufacturing.

YUBA

CONSOLIDATED INDUSTRIES, INC.

New York Sales Office: 530 Fifth Avenue
Branch Offices and Representatives in Principal Cities

Divisions Manufacturing Heat Exchangers

Yuba Heat Transfer Divison, Honesdale, Pa.
California Steel Products Division, Richmond, Calif.
Adsco Division, Buffalo, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

One in a series.

How to Select a Steam Trap Big Enough for the Job

Adequate capacity safety factors are essential to operating efficiency

As promised to you in a previous Armstrong trap advertisement in this publication, here is some helpful information on steam trap safety factors.

First, the definition. A trap safety factor is simply the ratio between actual continuous discharge capacity of the trap and normal condensate load. If the load is 500 lb/hr and the trap actually will discharge at the rate of 1000 lb/hr, the safety factor is said to be 2 to 1, and so on.

Why a Safety Factor?

You are not going to get maximum heat transfer efficiency from any steam heated unit unless your traps are sized with a generous excess of capacity over the normal condensate load.

Remember that trap capacity is given in terms of *continuous* discharge of condensate at a given pressure differential. If you don't employ an adequate safety factor, you make no provision for these requirements or conditions:

1. ***Venting of gas,*** O_2 and CO_2, would be impossible if a trap should discharge a full stream of water continuously.

2. ***Peak loads*** would back up condensate in the line or unit if the trap were sized for average load.

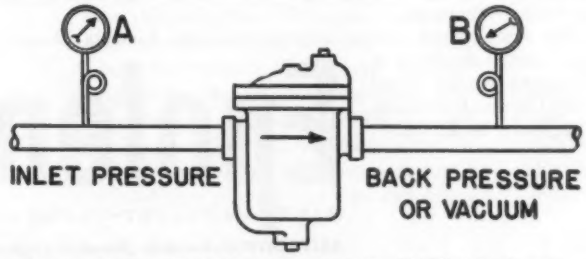
3. ***Reduction in pressure differential*** across the trap orifice would reduce capacity below requirements. If steam pressure drops below normal, trap capacity is lowered more than condensing rate. An increase in back pressure for any reason cuts trap capacity. And, pressure differentials often drop substantially during warming-up periods.

4. ***"Group" trapping.*** Very occasionally it is impractical to use an individual trap on each coil or condensing unit. Here, a generously oversized trap helps prevent backup of condensate or air from one unit to another. The frequent opening of a big trap valve "pumps" non-condensibles and condensate to the drain header.

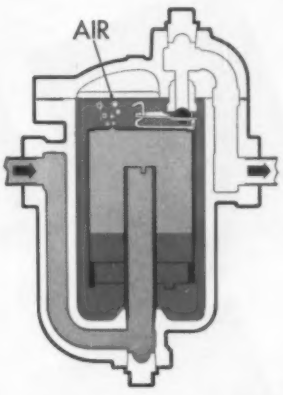
What Safety Factor?

Fortunately, it isn't necessary to calculate safety factors. Experience is the best guide and the benefit of experience with tens of thousands of successful installations is available to you. The following table is taken from the Armstrong Steam Trap Book.

Page	Equipment Drained	Safety Factors
24	Purifiers and Separators	2 or 3 to 1
25	Steam Mains or Headers	2 or 3 to 1
26	Steam Heating Pipes...	2 to 1 up to 6 to 1
29	Unit Heaters.....	3 to 1
30	Submerged Coils.....2,	3 or 4 to 1
32	Cylinder Dryers.....	4 to 1 up to 10 to 1



Pressure differential affects trap capacity. If "B" is back pressure, subtract from "A"; if "B" is vacuum, add to "A". Safety factors compensate for drops in pressure differential.



Traps vent air. This requires a trap capacity safety factor.

The page numbers listed contain completely reliable data for any trapping job.

CAUTION. The safety factors recommended in The Armstrong Steam Trap Book will have to be increased by an unknown factor for trap capacity ratings based on cold water tests, orifice tests or slide rule calculations. Armstrong trap steam temperature condensate capacity ratings are based on actual operating conditions which take into account such capacity-reducing factors as pipe friction and the choking effect of flash steam.

If you'd like to have a copy of the 44-page Steam Trap Book, just call your local Armstrong Representative, or write the factory. There is no obligation.

Armstrong Machine Works
8526 Maple Street
Three Rivers, Michigan

ARMSTRONG STEAM TRAPS

For more data on advertised products, use Readers' Service Cards, last page.

Assures control of paraffin viscosity

EPOLENE "N"

Viscosity control of paraffin formulations calling for the addition of polyethylene is assured—if Epolene "N", Eastman polyethylene wax, is used. Because uniformity of coating paraffins is so important, Eastman takes special care to produce Epolene between narrow limits of viscosity.

Published specifications for the viscosity of Epolene "N" are within the range of 2200 and 2700 cps at 125° C—your assurance of close control and uniformity from batch to batch.

The table shows what this uniformity means in polyethylene-based paraffin formulations. Five percent samples of Epolene "N", from the *extremes* of our production range, were mixed with paraffin—and the viscosities of the resulting mixtures were taken on the same Brookfield Viscometer.

Sample	Viscosity at 200° F (cps)
100% paraffin	4.8
95% paraffin—5% Epolene "N" (2250 cps)	7.5
95% paraffin—5% Epolene "N" (2700 cps)	7.6

Although viscosity varies from paraffin to paraffin, these results dramatize the advantage of using Epolene "N". Thus, for the paraffin under test, the maximum variation encountered in the final viscosity of the 5% Epolene blend was only 0.1 centipoise.

To assist manufacturers in taking full advantages of the outstanding properties of Epolene "N", Eastman maintains an extensive technical service laboratory in Kingsport, Tennessee. Through this laboratory, paraffin formulators are offered expert assistance in formulations and manufacturing techniques.

For samples and further information, write Eastman Chemical Products, Inc., subsidiary of Eastman Kodak Company, Chemicals Division, Kingsport, Tennessee.

Epolene

EASTMAN POLYETHYLENE WAXES

SALES OFFICES: Eastman Chemical Products, Inc.
Kingsport, Tennessee; New York City; Framingham Mass.; Cincinnati; Cleveland; Chicago; St. Louis; Houston
West Coast: Wilson Meyer Co., San Francisco Los Angeles; Portland; Salt Lake City; Seattle

For more data on advertised products, use Readers' Service Cards, last page.

lube oils for IRAQ

New 25,000 ton/year plant
completed by Foster Wheeler in 24 months

Recently completed for the Government of Iraq, this new plant near Baghdad provides the most modern facilities for producing a full range of lubricating oils. Designed and built from the ground up by Foster Wheeler, Ltd., London, with materials purchased from European sources, it includes vacuum distillation, propane deasphalting, furfural solvent refining, propane dewaxing, clay percolation, asphalt oxidation and blending facilities, as well as the steam and power plant, storage tanks and modern equipment for can and drum manufacture, compounding and filling.

Despite transportation delays due to Middle-East political complications, the plant was completed and on stream *on schedule* — just 24 months from award of contract.

Foster Wheeler has also been awarded a contract for a major modernization program of the gasoline-fuel oil section of this refinery — including expansion of existing combination unit, installation of new Powerforming and kerosene treating units and substantial offsite facilities.

FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

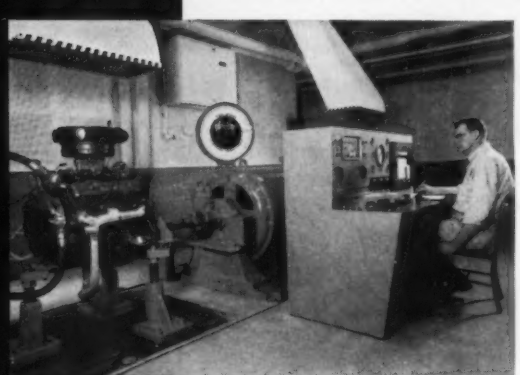
What took the spark

This unretouched photograph, taken by Edmund F. Hawes, UOP Staff Photographer, was awarded First Prize in the 1956 ASTM Photographic Exhibit.

For more data on advertised products, use Readers' Service Cards, last page.

out of this plug?

The old problem of the fouled-up spark plug is less acute today because of modern improvements in petroleum refining. Most refiners are taking the utmost precautions to make sure that the motor fuels they produce burn clean, quick and with the full power needed for today's high compression, high-speed engines. Throughout the refining industry research technicians are constantly checking the fuels their refineries produce to help guard against plug fouling and to maintain all the high performance characteristics demanded by today's automotive engines. In this way they are helping to make and keep the products you market salable. Here at UOP, in our business of developing processes for the manufacture of motor fuels, we also never take our eyes off the performance of the end product. Our research and technical staffs are constantly concerned with the fuels made by UOP processes to make sure that these will have the performance qualities that will give their ultimate users full satisfaction. This is only part of the broad contribution research is making toward the salability of products from petroleum. Wherever you market, you can be sure that "men of science" are constantly working to keep the products you sell at the quality level your customers demand.



This is a modern V-8 engine and dynamometer used in the UOP Engine Laboratory to analyze all phases of motor fuel performance including engine cleanliness test. It is one of the tools used by UOP technicians to develop methods for producing fuels having all of the characteristics necessary to satisfy the petroleum marketers' most demanding customers.

UOP

More Than Forty Years Of Leadership In Petroleum Refining Technology

UNIVERSAL OIL PRODUCTS COMPANY

30 Algonquin Road, Des Plaines, Illinois, U. S. A.

For more data on advertised products, use Readers' Service Cards, last page.

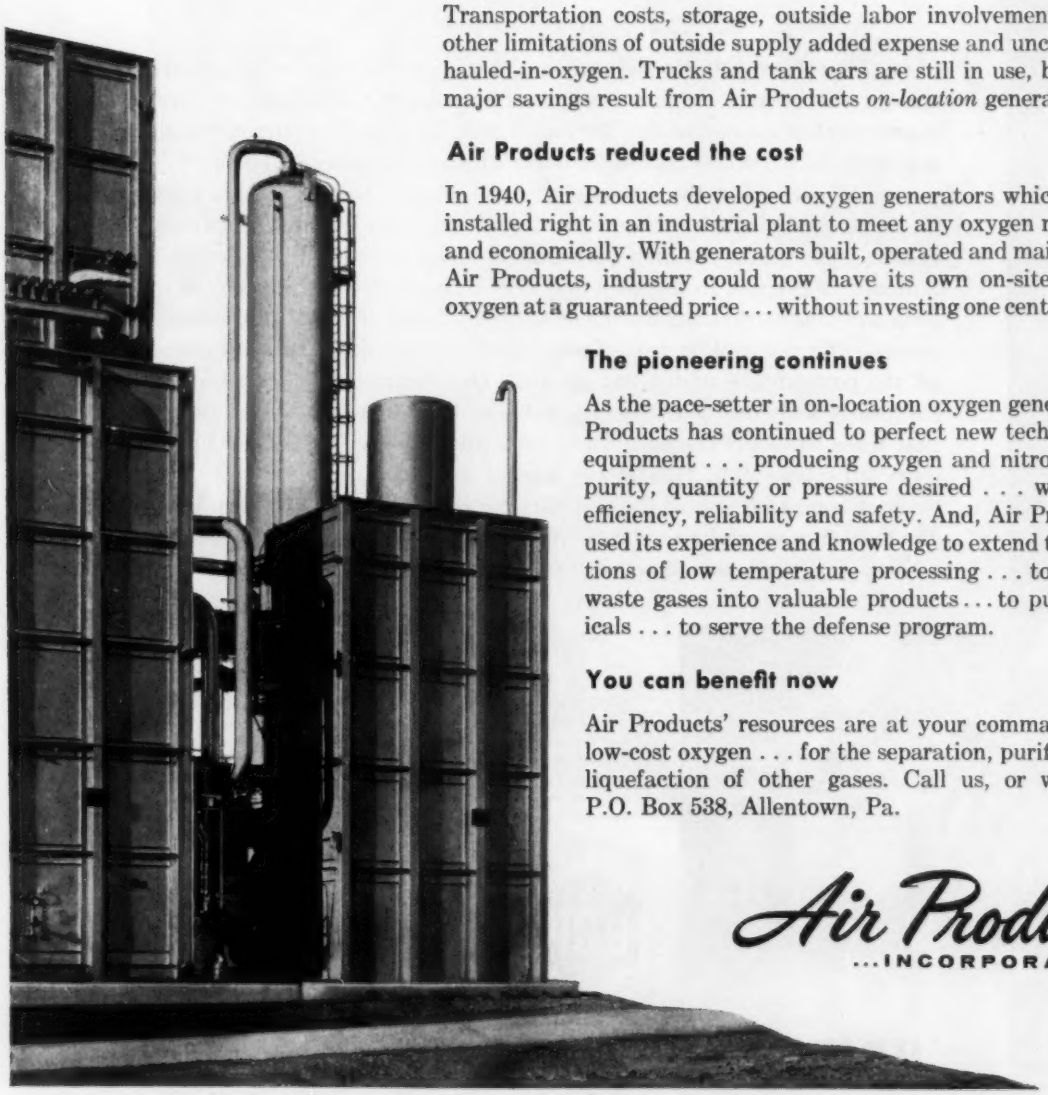
What happened to the price of oxygen?

The price of bulk oxygen has dropped about 80% in 12 years, while most other prices have risen. Oxygen is now being produced in large quantities for a few dollars per ton.

Oxygen isn't the high-priced chemical it used to be. Now, it's a low-priced tonnage commodity—a utility purchased like electricity or water. The price drop is the *real reason* oxygen usage has climbed beyond 70 billion cubic feet per year.

Why was it costly?

Transportation costs, storage, outside labor involvements and the other limitations of outside supply added expense and uncertainty to hauled-in-oxygen. Trucks and tank cars are still in use, but today's major savings result from Air Products *on-location* generation.



Air Products reduced the cost

In 1940, Air Products developed oxygen generators which could be installed right in an industrial plant to meet any oxygen need, safely and economically. With generators built, operated and maintained by Air Products, industry could now have its own on-site supply of oxygen at a guaranteed price . . . without investing one cent of capital.

The pioneering continues

As the pace-setter in on-location oxygen generation, Air Products has continued to perfect new techniques and equipment . . . producing oxygen and nitrogen in any purity, quantity or pressure desired . . . with greater efficiency, reliability and safety. And, Air Products has used its experience and knowledge to extend the applications of low temperature processing . . . to transform waste gases into valuable products . . . to purify chemicals . . . to serve the defense program.

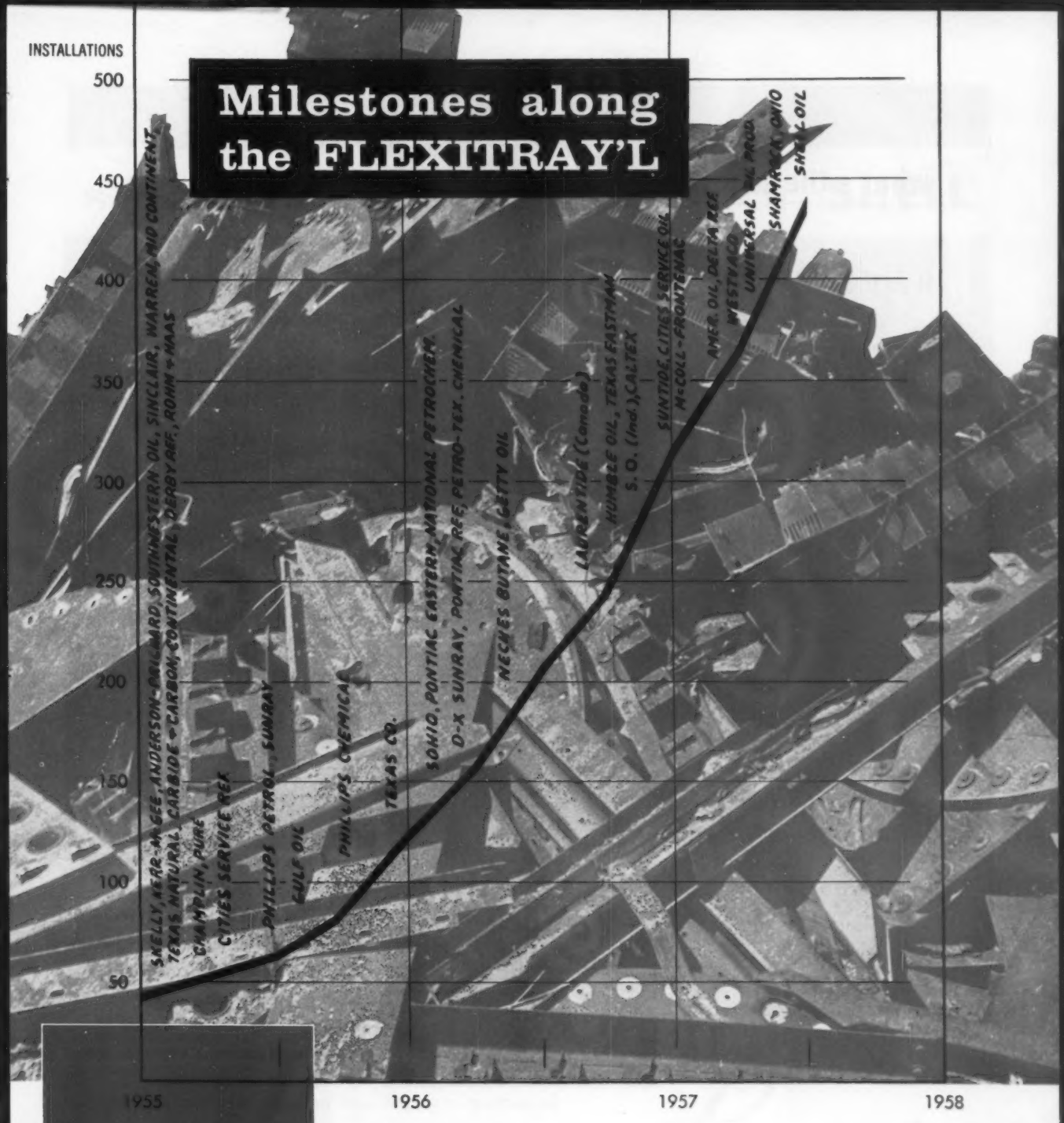
You can benefit now

Air Products' resources are at your command . . . for low-cost oxygen . . . for the separation, purification and liquefaction of other gases. Call us, or write us at P.O. Box 538, Allentown, Pa.

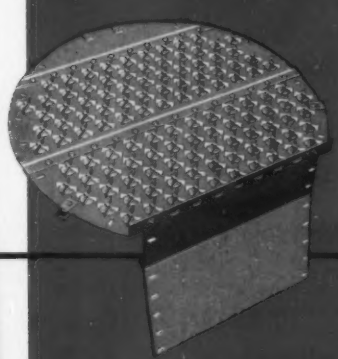
Air Products
...INCORPORATED

Hundreds of Air Products package generators and tonnage plants are now on stream . . . capacities range from ⅓ ton to 500 tons per day.

Milestones along the FLEXITRAY'L



*Dates of original orders only, reorders not shown.



REPRESENTATIVES

KOCH ENGINEERING COMPANY, INC.

DESIGNERS AND FABRICATORS OF MODERN TRAYS

321 WEST DOUGLAS AVENUE, WICHITA 2, KANSAS

Eastern Representative: F. J. McConnell Company, 122 East 42nd Street, New York 17, New York
Tulsa, Oklahoma Representative: W. C. Myers Company, Wright Building
Houston, Texas Representative: Alpha Engineering Company, P. O. Box 12371
Pittsburgh, Pennsylvania Representative: D. D. Foster Company, 501 Alcoa Building
West Coast Representative: Jacobs Engineering Company, Pasadena: RYan 1-9373; Oakland: TEmplebar 2-5391
Illinois Representative: M. B. Fisher, 1521 Courtland Avenue, Park Ridge, Illinois

what's the secret

why is Caposite so strong?

It's no secret why CAPOSITE insulation is so strong and stands up to such rough usage. These pipe sections and blocks are made wholly of Amosite asbestos and the long fibres of this particular kind of asbestos give CAPOSITE its strength and resilience as well as its high insulating value. This exceptional strength leads to many other features besides long life; it means that larger sizes of pipe sections and blocks are possible, making application easier and faster. Less care is needed in handling the material. Unlike other moulded insulation, CAPOSITE, because of its strength, can be shipped to refineries anywhere in the world *in cardboard cartons*, showing big savings in freight and storage costs.

CAPOSITE Regd.

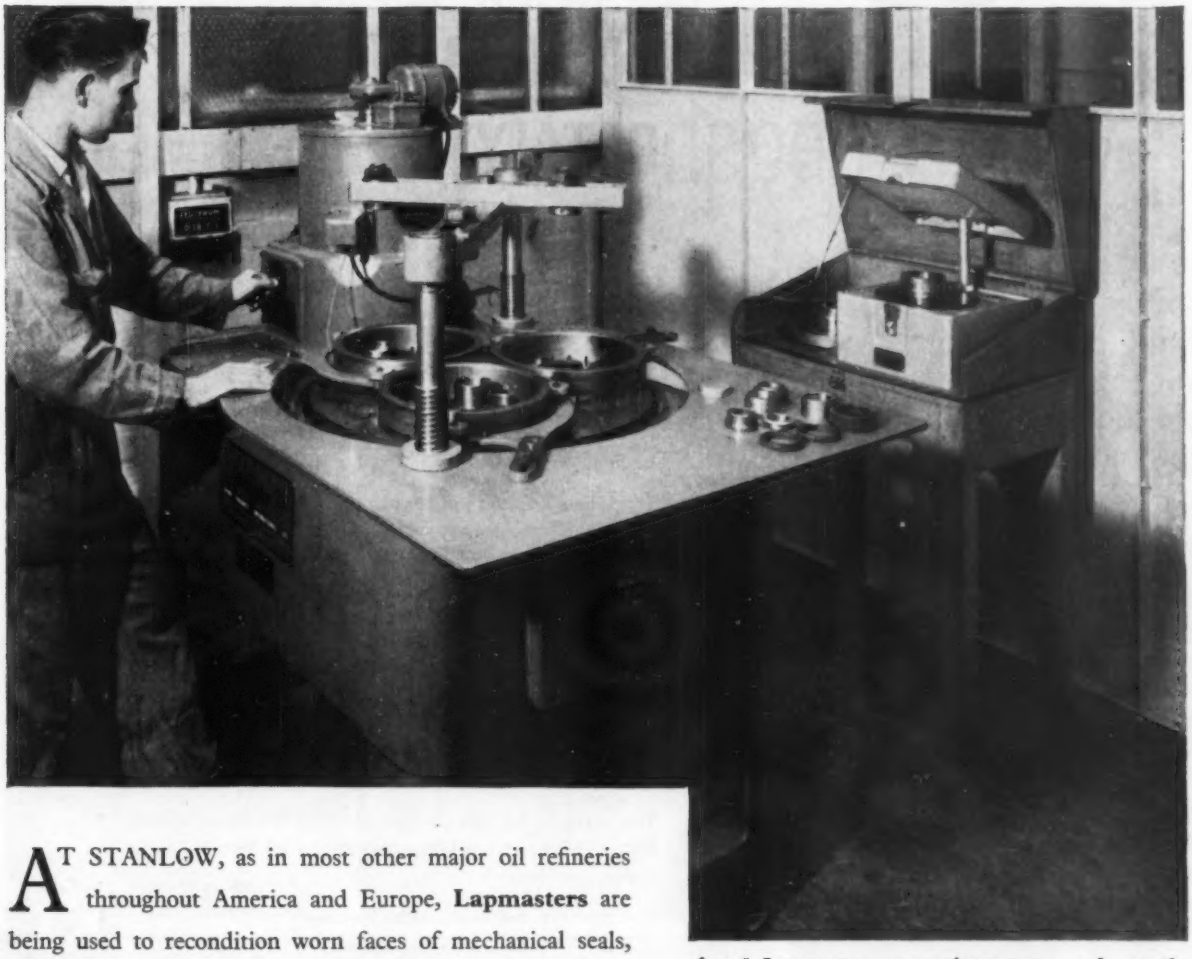
ASBESTOS INSULATION

THE CAPE ASBESTOS COMPANY LIMITED, 114 & 116 PARK STREET, LONDON W1 Tel: Grosvenor 6022 Cables: Incorrupt London

Enquiries in Canada to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario
U.S.A.: North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois

TA 10643

smooth performance for **SHELL**



*A 24" **Lapmaster** on maintenance work at the Stanlow Refinery of* **Shell Refining Company Limited.**

AT STANLOW, as in most other major oil refineries throughout America and Europe, **Lapmasters** are being used to recondition worn faces of mechanical seals, gas compressors, valve discs, wedges of gate valves and other parts where flat, smooth surfaces are essential to satisfactory performance. In many cases the **Lapmaster** has recovered its cost in two years on the salvaging of mechanical seal faces alone.

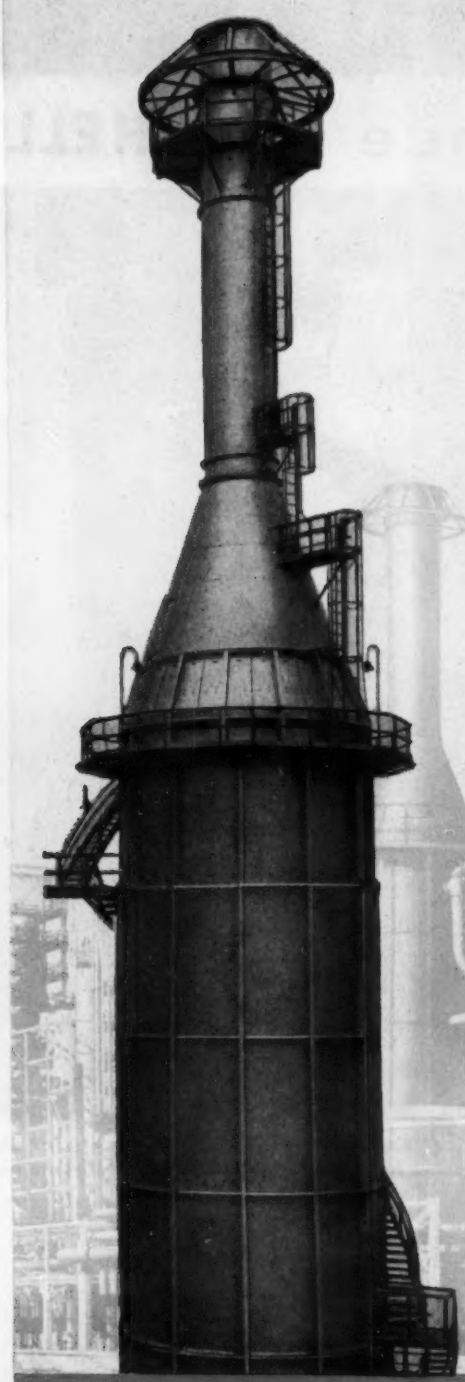
Lapmaster

The **Lapmaster** is an automatic precision machine for the high-speed, low-cost lapping of all materials in any production quantities. In addition to controlled flatness to one light band (.0000116 of inch), surface finish to one micro-inch can be achieved by using **Lapmaster** abrasives.

For full particulars of 12", 24" & 36" **Lapmasters,** *please write to*

PAYNE PRODUCTS INTERNATIONAL LTD.
Lawrence Estate, Green Lane, Hounslow, Middlesex, England. Telephone: HOUnslow 1718.

For more data on advertised products, use Readers' Service Cards, last page.



ISOFLOW FURNACES NOW PROCESSING 300,000 b/d IN CATALYTIC REFORMERS

. . . and more "Isoflows" are being installed in the largest reformers under construction

The continuous production of high octane gasoline by catalytic reforming demands sturdy, efficient, soundly designed equipment. This is especially true of furnaces.

The wide acceptance of Petrochem-Isoflow furnaces is due to their high efficiency, dependable performance even under overload conditions, and their long service life. When you apply all the specifications and operating requirements to direct fired furnace design you'll find Petrochem-Isoflows most economically desirable, by any comparison.

For petroleum, chemical and allied process industries there's a Petrochem-Isoflow furnace for any duty, temperature and efficiency.

The unique design and operating features which have led to the wide acceptance of Petro-Chem furnaces include:

- **Uniform Heat Distribution**
- **Maximum Fuel Efficiency**
- **Low Pressure Drop**
- **Low Maintenance**
- **Zero Air Leakage**
- **Minimum Ground Space**
- **Simplicity of Design and Construction**
- **Short Length of Liquid Travel**
- **Series, Multipass, all parallel flow**
- **Excess Draft for High Overload**

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

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Rawson & Co., Houston • Wm. H Mason Co., Tulsa • Lester Oberholtz, Los Angeles • Pavillo-Levally, Chicago • D. D. Foster, Pittsburgh • Turbon, Philadelphia • Flagg, Brackett & Durgin, Boston • G. M. Wallace & Co., Denver & Salt Lake City

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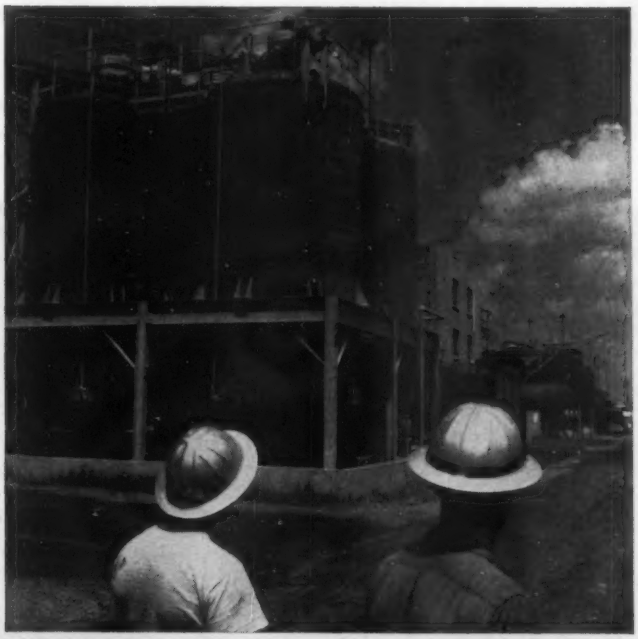
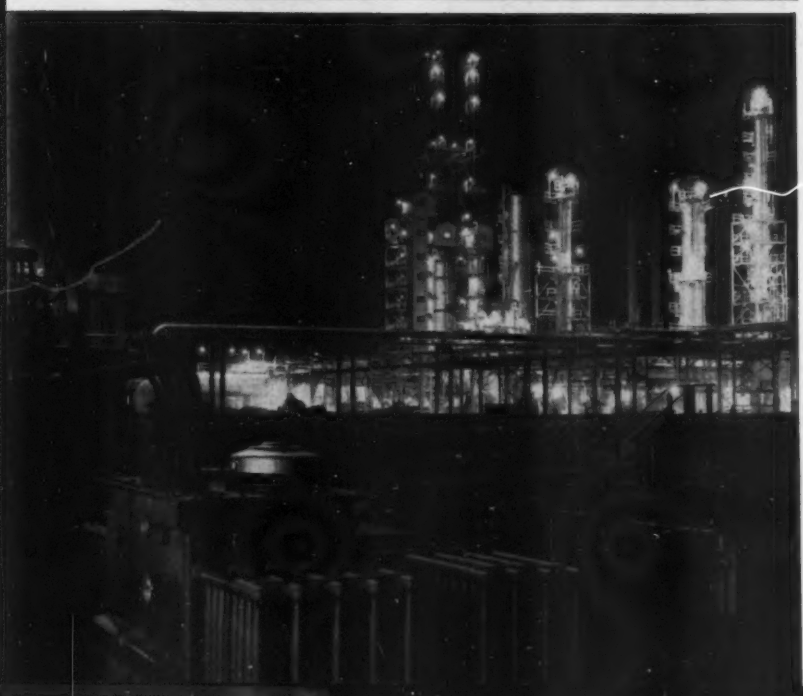
To protect process growth . . .

Take a new look at electrical system dependability



These chemical and petroleum companies did . . . and found new advantages in Westinghouse distribution equipment and engineering counsel.

American Cyanamid and Westinghouse Engineers worked out a power distribution system that prevents outages. If there's trouble on any feeder, power is switched to another. If a substation faults, other substations carry the load through cross connections. This system can be easily and inexpensively expanded as the plant grows.



Sohio's Lima Refinery achieves power dependability without paying extra for stand-by capacity. In a period of over two years, this Westinghouse equipped system handled power interruptions without loss of refinery production.

Get economy with system protection →

YOU CAN BE SURE... IF IT'S

Westinghouse

Call Westinghouse early to . . .

coordinate equipment for low cost, power dependability

Early planning of your power distribution system is the only effective way to answer these basic questions:

1. **How can I get the most reliability for dollars spent?**
2. **Will my electrical system be adaptable to changing load conditions with minimum service interruptions?**
3. **Can I get good voltage regulation in spite of load fluctuations?**

1. Standardized type SL transformers — liquid filled substation transformers for chemical use offer the many economies of Westinghouse standardization and design advantages based on years of tested and proved experience.

The choice of types of equipment and power distribution layout will depend on the problems in your plant . . . change-over, expansion, modernization, new processes or products. Westinghouse can help you select the right equipment and coordinate it to bring out the specific advantages that best suit your requirements.

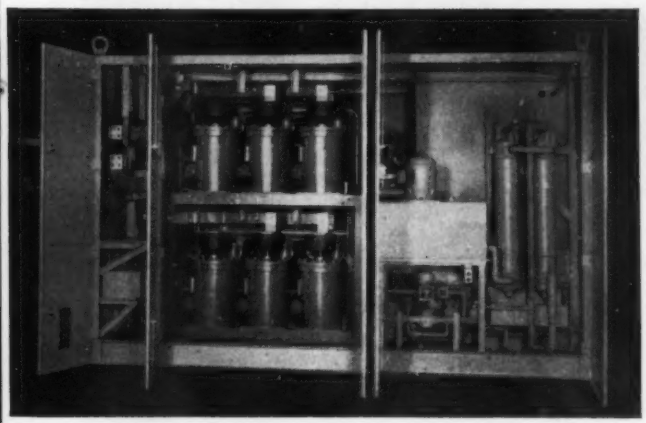
Here are brief descriptions of the advantages you'll find in Westinghouse apparatus for a proven distribution system. They suggest many ways to provide maximum reliability without the expense of standby facilities.

Discuss your plans with your Westinghouse Sales Engineer, or write: Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

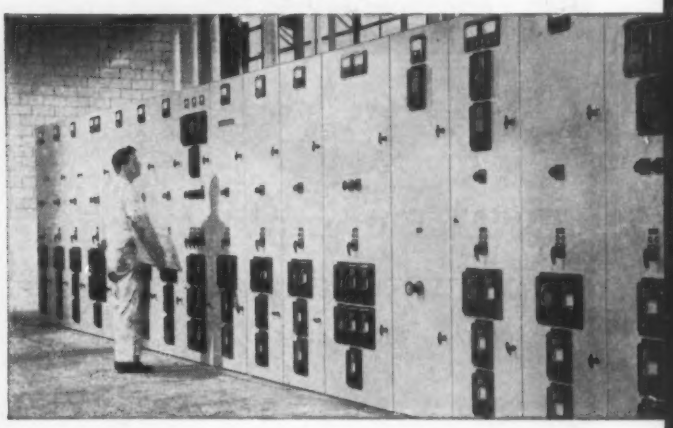
MP-3054

YOU CAN BE SURE...IF IT'S Westinghouse

2. Westinghouse oil circuit breakers with automatic reclosing equipment can automatically restore service to protect incoming lines or feeder circuits from prolonged and costly outages.



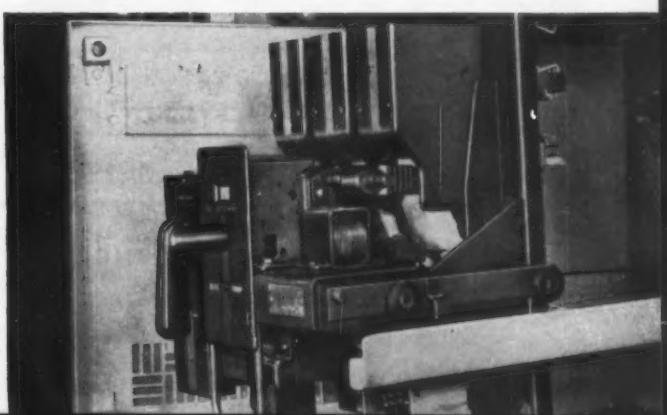
3. High availability and low maintenance of Westinghouse Ignitron Rectifiers has resulted in electrochemical installations totaling millions of kilowatts. Units are completely metal enclosed and factory assembled for low installation cost, minimum floor space.



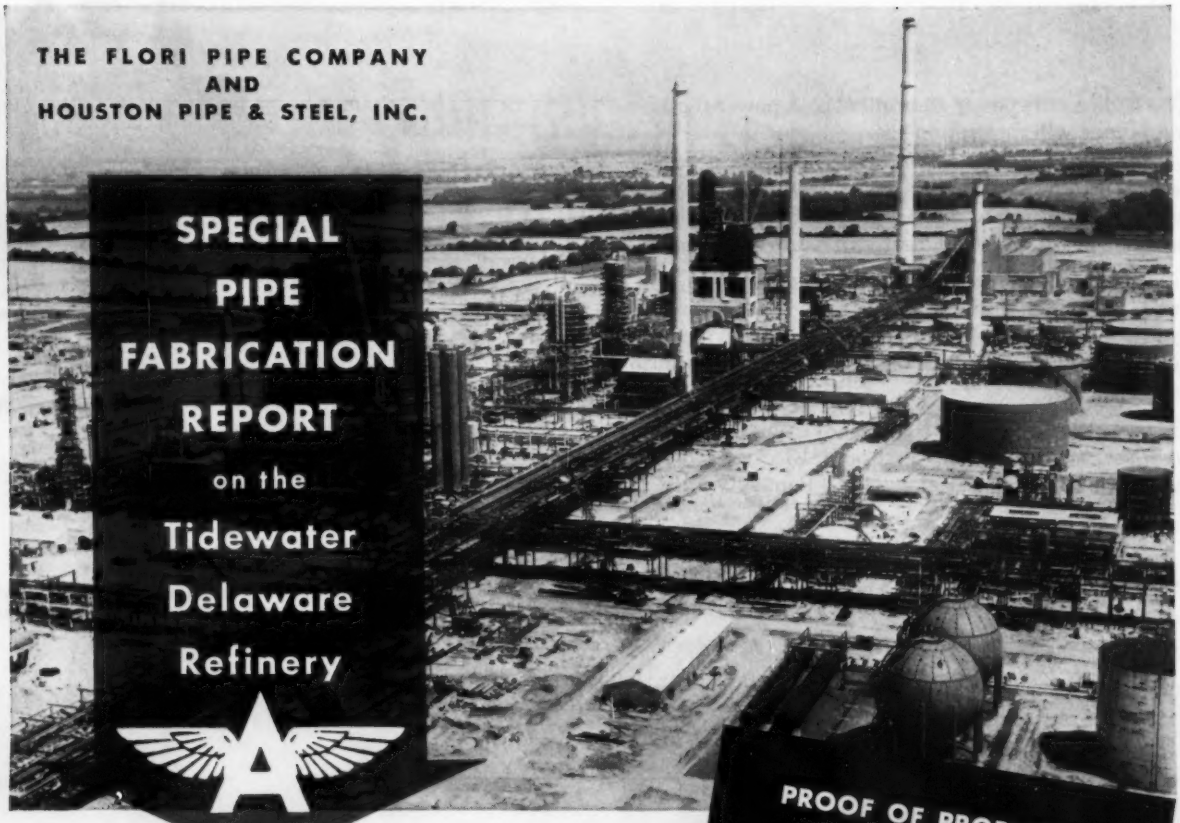
4. Westinghouse Metal-Clad High Voltage Switchgear provides unusual safety through interlocking devices and full steel barriers in a completely compartmentalized design.

5. Westinghouse unitized dry-type power centers solve the problem of handling increased power loads economically. They cost less to install because they do not require expensive enclosures and can be located close to the center of the load. For expansion, install additional breakers in spare feeder compartments.

6. Westinghouse low-voltage switchgear design provides an unusual degree of flexibility. This results from modern selective tripping. You get perfect coordination of time-delay characteristics, which confines outages to the faulted section alone.



THE FLORI PIPE COMPANY
AND
HOUSTON PIPE & STEEL, INC.



SPECIAL
PIPE
FABRICATION
REPORT
on the
Tidewater
Delaware
Refinery

PROOF OF PRODUCTION AND DELIVERY SKILL APPARENT IN HUGE DELAWARE REFINERY OF TIDEWATER OIL CO.

FLORI completes reported largest alloy pipe fabricating project ever undertaken...

The Flori-Houston fabrication of substantially all alloy piping for Tidewater Oil Company's gigantic Delaware Refinery constitutes the reported largest alloy pipe fabricating project ever undertaken. Situated 15 miles south of Wilmington, Delaware, on a 5,000 acre site, it is the largest petroleum refinery ever built at one time.

Into this gigantic refinery went incredible quantities of fabricated pipe of numerous sizes and various metallurgical content. This project required almost 250 miles of piping. Flori-Houston delivered more than 1500 tons of fabricated alloy piping.

Approximately 1400 separate units, averaging more than a ton apiece in weight and needing more than 20,000 blueprints, were fabricated. Operational requirements in the refinery included temperature ranges to 950 F. and pressure ranges to 1350 lbs. per sq. in. To meet these requirements Flori fabricated thirteen different alloys, including nickel, monel, inconel, and incoloy.

A truly amazing feature of the project was the tight quality control program required throughout. Specifications for the job required 100% penetration—without the use of backing rings—for all welds.

This is just more proof that the Flori-Houston skill and experience can handle any fabricating job expertly, efficiently and economically.

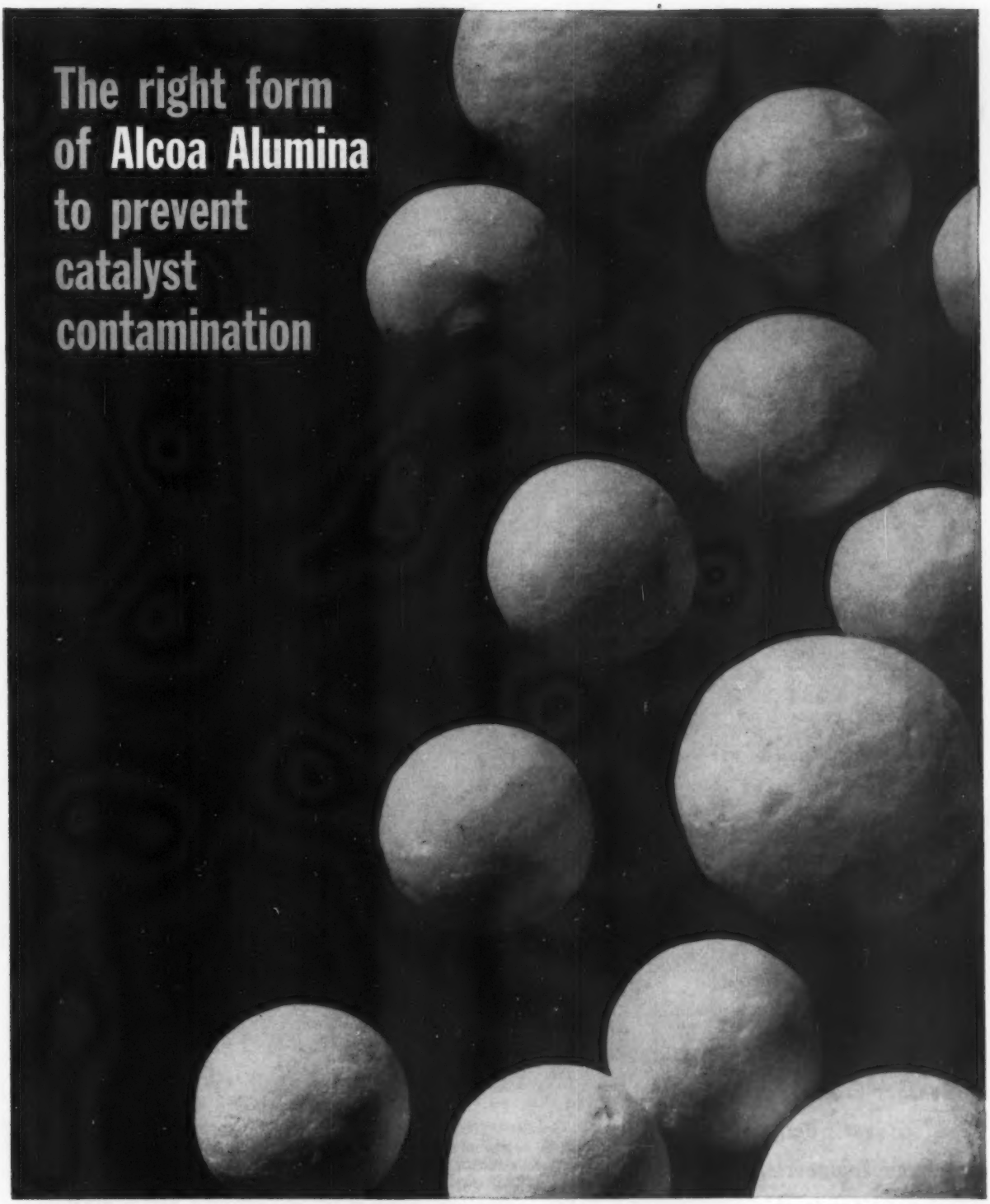
SEE HOW THIS COMPETITIVE SERVICE AND PRODUCTION CAN WORK FOR YOU.

SEND FOR FREE BROCHURE...
This illustrated 16-page brochure shows every stage of the new Flori-Houston operation.

GENERAL OFFICE
THE FLORI PIPE CO.
601 E. RED BUD • ST. LOUIS 15, MISSOURI

HOUSTON OFFICE
HOUSTON PIPE & STEEL, INC.
P. O. BOX 2 • HOUSTON 1, TEXAS

subsidiaries of
SPARTON CORPORATION



Tabular Balls for bed supports, packing and covers—Neutral, nonreactive, highly refractory and abrasion resistant, ALCOA® Tabular Alumina Balls will not contaminate catalysts or influence reactions. Of highest purity sintered alumina (+99.5% Al_2O_3), they are unaffected by oxidizing or reducing atmospheres below 3500°F... are practically insoluble in acid and alkaline solutions. They are available in sizes from ⅛" to ¾" diameter—and in grades to meet specific needs.

Don't let contamination raise *your* catalyst costs! Use ALCOA Tabular Alumina Balls for bed supports, covers and packing. For detailed information and samples, write ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 717-K Alcoa Building, Pittsburgh 19, Pennsylvania.

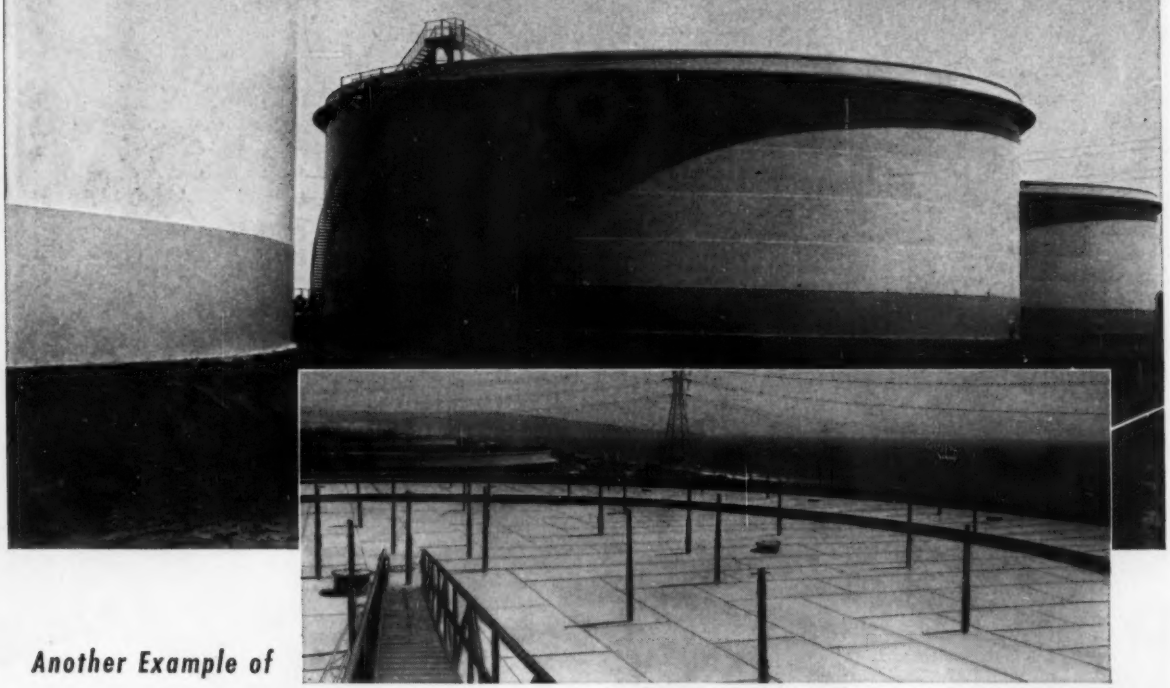
ALCOA CHEMICALS

NEW!
"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

For more data on advertised products, use Readers' Service Cards, last page.

GRAVER solves wax deposit problem with specially designed scraper shoes in

3 NEW CENTER-WEIGHTED PONTOON FLOATERS FOR STANDARD OIL COMPANY OF CALIFORNIA



Another Example of Graver's Design and Engineering Leadership

These three new Graver 160,000 bbl. floating roof tanks, with the center weight *under the deck*, were selected by Standard Oil Company of California as suitable for high wax content crude. This type crude may create a problem of wax build-up on the tank shell. Graver designed a special shoe of Type 304 stainless steel to provide a scraper action as the roof descends. This stainless shoe and the unique, lower-cost under-deck center-weighted roof design are examples of Graver's imaginative design and engineering leadership.

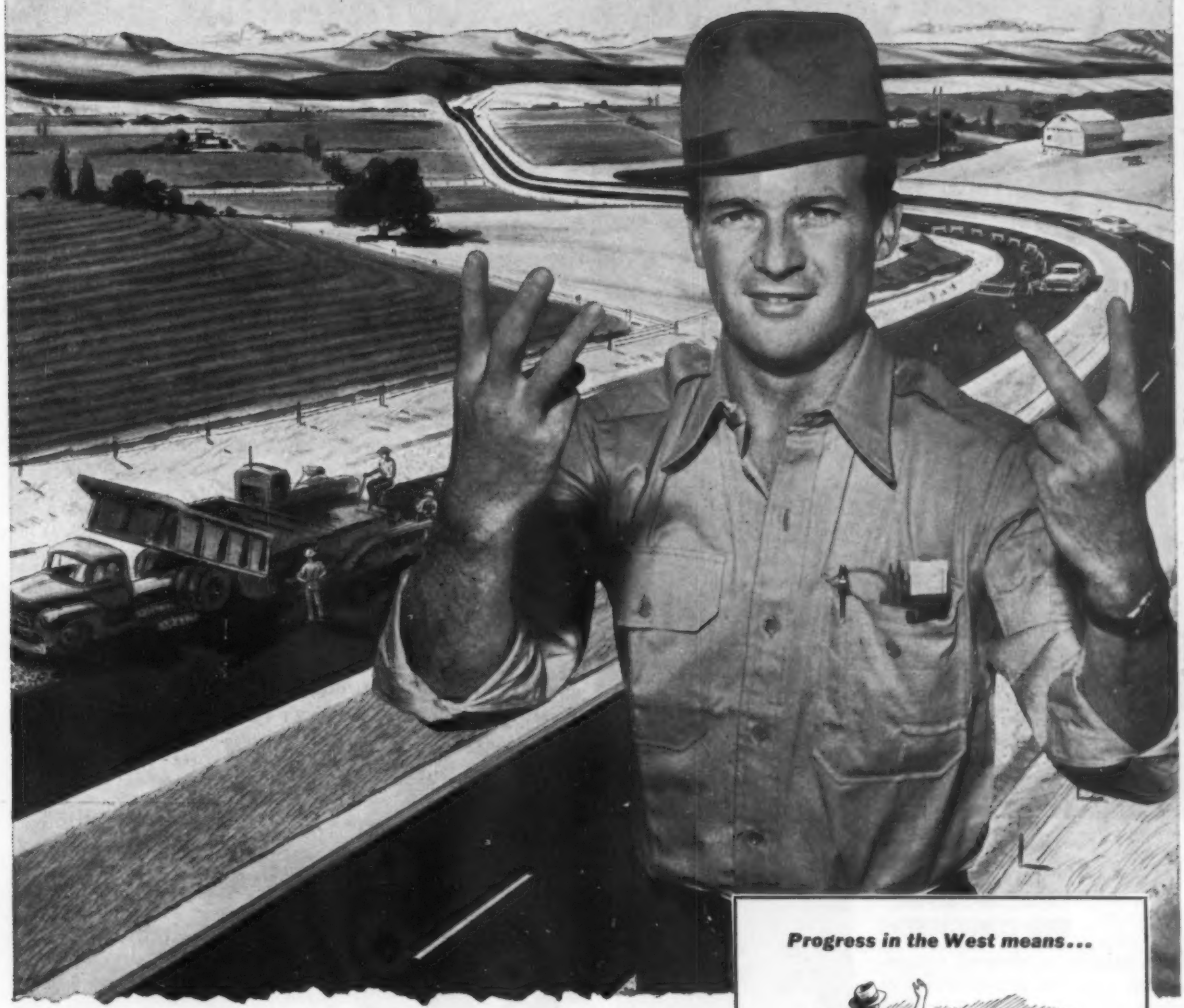
1857-1957 GRAVER® Our 100th Year

Building for the Future on a Century of Craftsmanship in Steels and Alloys

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA • NEW YORK • PHILADELPHIA • EDGE MOOR, DELAWARE
PITTSBURGH • DETROIT • CHICAGO • TULSA • SAND SPRINGS, OKLAHOMA
HOUSTON • NEW ORLEANS • LOS ANGELES • SAN FRANCISCO • FONTANA, CALIFORNIA

How Standard helps your tax dollars buy 3 miles of superhighway for the cost of 2



Asphalt can save billions of dollars on the 41,000 miles of superhighways the U.S. will build in the next 15 years

Heavy Duty Asphalt Costs 20% to 50% Less Than Other Pavements. This means extra miles of superhighways for your tax dollars . . . smoother, more enjoyable miles, too. Safe, skid-resistant asphalt cuts down headlight and sunlight glare, makes lane markers easy to see.

To help bring you more miles of superroads faster and at lowest cost, Standard* operates nine asphalt refineries across the nation. Our scientists work with highway engineers on improved construction methods and the kind of low-cost maintenance that can make asphalt highways even better and stronger after many years of service.

Progress in the West means...

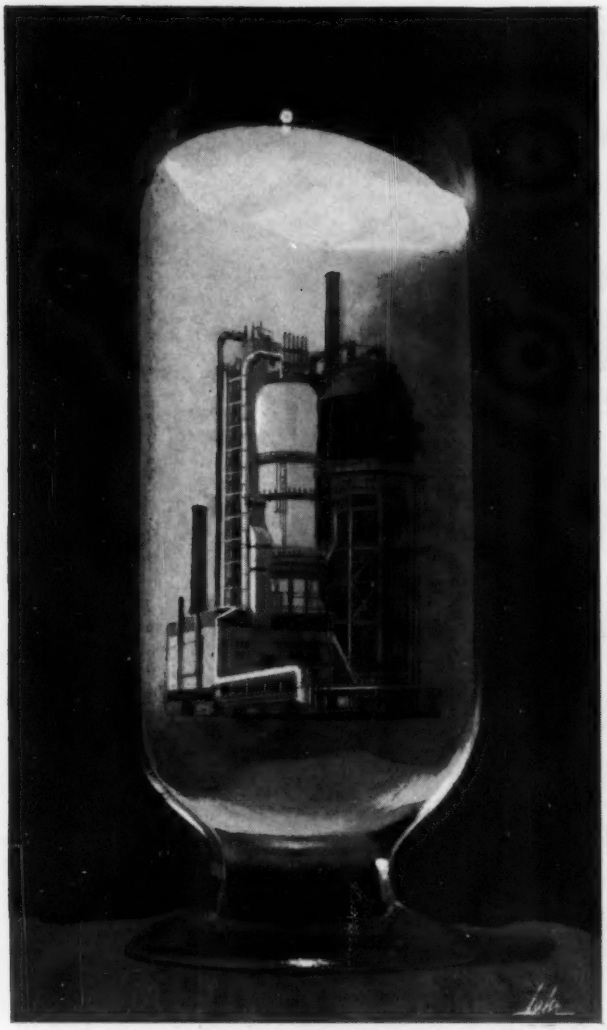
over 50,000 miles of new and improved highways by 1970

**Through Standard's wholly owned subsidiary, American Bitumuls and Asphalt Company*

STANDARD OIL COMPANY OF CALIFORNIA

plans ahead to serve you better

For more data on advertised products, use Readers' Service Cards, last page.



A working partnership with refiners has produced

CYANAMID'S Aerocat® Catalysts

...with "Balanced Performance" efficiency

Field performance is what counts! That's why actual *operating* values for activity, selectivity, attrition rate, pore volume, surface area and other factors affecting catalyst performance are obtained by Cyanamid technical teams working with the refinery engineers of cracking units. It is the evaluation of this data that determines current Cyanamid catalyst specifications to insure a *"Balanced Performance"* — AEROCAT Catalysts that give maximum over-all efficiency in refinery use.

Your Cyanamid representative can provide extensive data relating to the use of AEROCAT Catalysts in *your* cracking operations.

PROBLEM-SOLVING MUD CONDITIONERS

High stability at elevated temperatures, or in the presence of contaminants, makes CYPAN® Drilling Mud Conditioners ideal for even difficult drilling operations. This high molecular weight acrylic-type polymer is effective even at high dilutions — has outstanding fermentation resistance and is unsurpassed in duration of water-loss control.

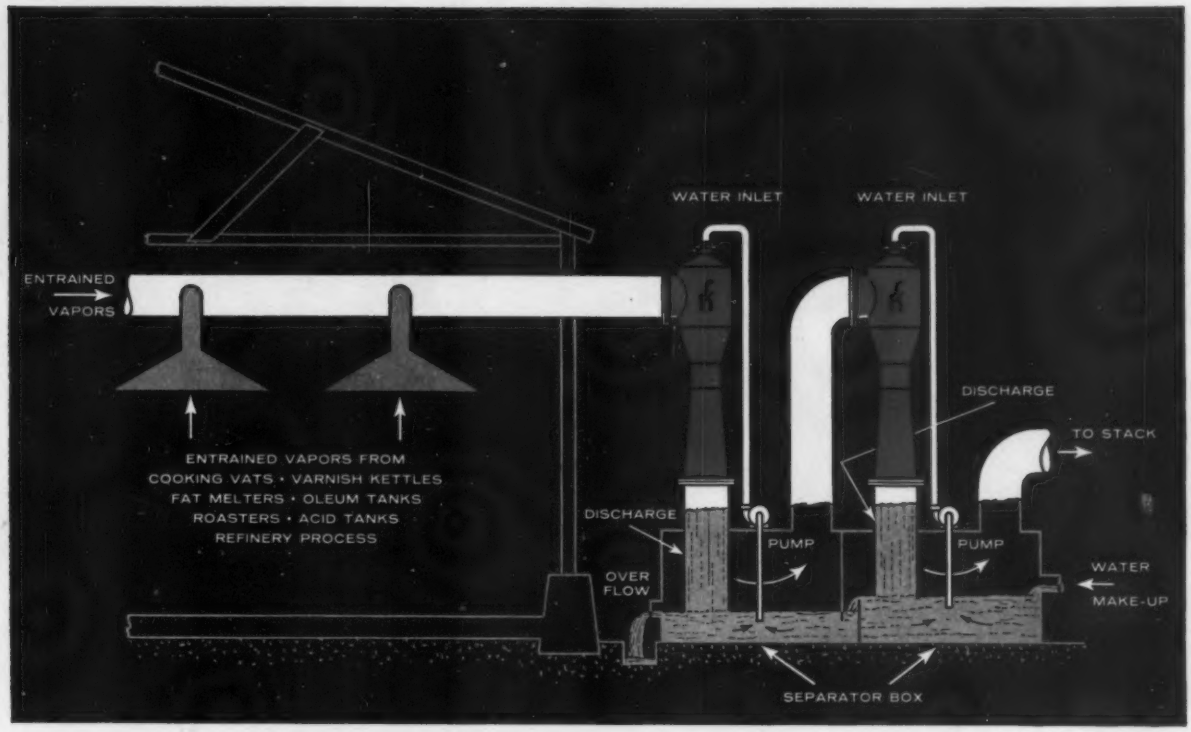
PLATINUM CATALYSTS BOOST OCTANE

Even low naphthene stock responds to the excellent catalytic action of AEROFORM® PHF Platinum Reforming Catalysts. These highly refined platinum-promoted alumina base catalysts are highly selective, regenerate easily and provide high octane levels with each reforming process.

CYANAMID

AMERICAN CYANAMID COMPANY, REFINERY CHEMICALS DEPARTMENT

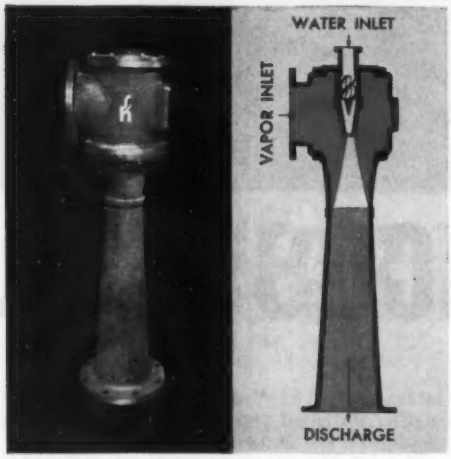
30 Rockefeller Plaza, New York 20, N. Y. • In Canada: North American Cyanamid Limited, Toronto and Montreal



CONTROL OBJECTIONABLE FUMES, GASES, VAPORS

with an economical SK Fume Scrubber

Photo and sectional drawing of
an SK Fig. 4010 Fume Scrubber



A food plant in California uses an SK Fume Scrubber to condense steam and scrub oil vapors from cooking vats. A large chemical manufacturing plant on the eastern seaboard uses a battery of SK Fume Scrubbers to condense steam and purge entrained gas containing H_2SO_4, SO_2, H_2S, TiO_2, and ore dust. A mid-western manufacturer uses SK Fume Scrubbers to vent oleum tanks. A soap maker in Pennsylvania uses a scrubber to remove ammonia fumes from a plant building and cool the building at the same time.

From coast to coast, chemical and food processing plants, refineries, paint and varnish manufacturers, fertilizer, and other manufacturing plants are using SK Fume Scrubbers to control objectionable—sometimes dangerous—fumes, gases, vapors, and dusts.

These manufacturers have found that SK Fume Scrubbers are reasonably low in initial cost, require little maintenance, and are an effective means for conforming to local ordinances which prohibit the pollution of air.

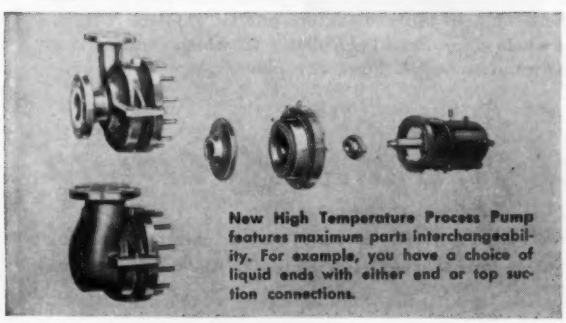
Made in a wide range of sizes from cast iron, steel plate, Haveg, stoneware, or other materials or with linings of rubber or Polyvinyl Chloride, or other synthetic materials, SK Fume Scrubbers can help you solve a fume or dust problem. Why not get the whole story. Send for Bulletin 4R which contains complete information on SK Fume Scrubbers.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin 10-RA.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin 17-A.

Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS SINCE 1876
2257 State Road, Cornwells Heights, Bucks County, Pa.

For more data on advertised products, use Readers' Service Cards, last page.

NOW! A LOWER COST ALL-

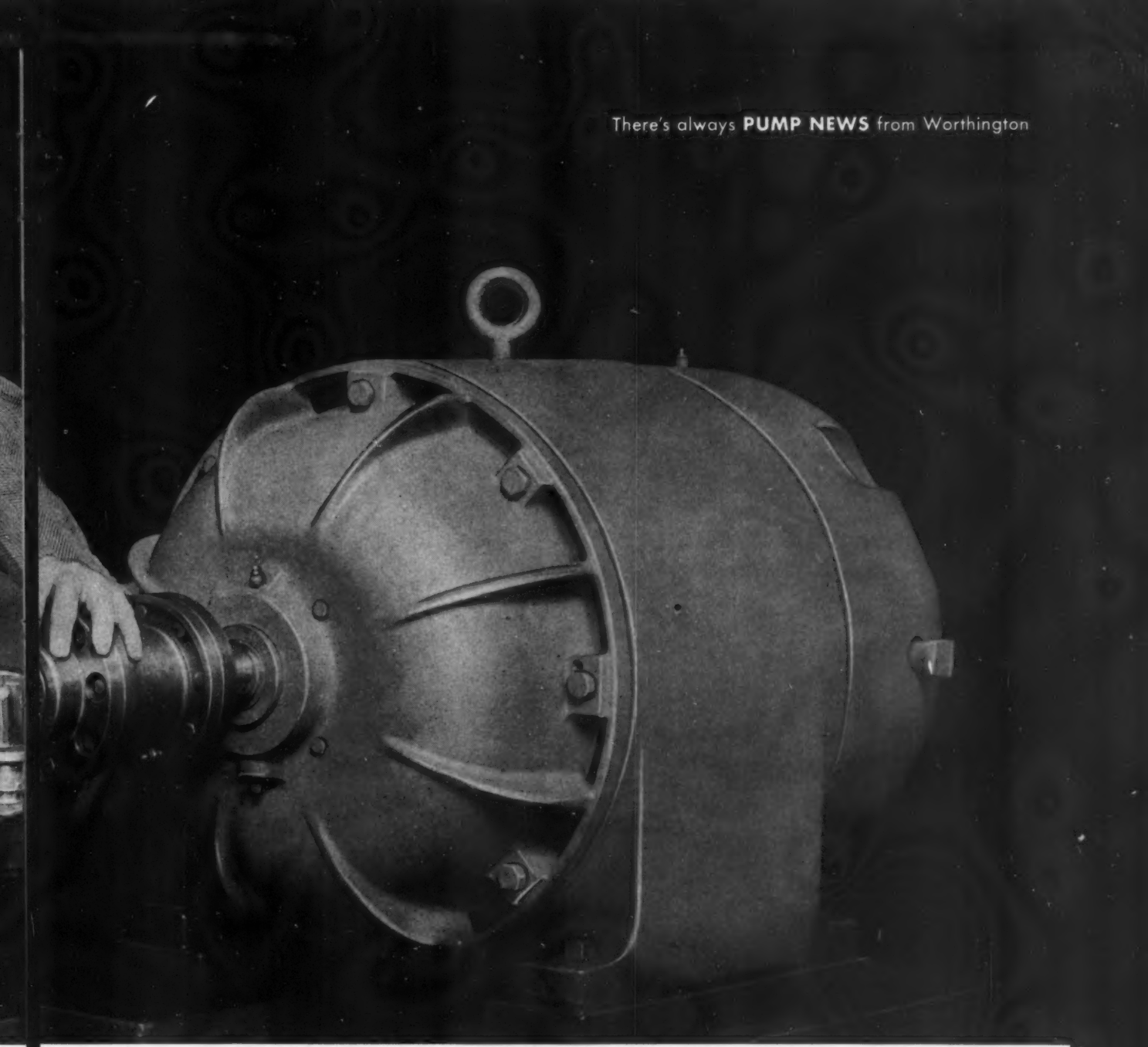


New High Temperature Process Pump features maximum parts interchangeability. For example, you have a choice of liquid ends with either end or top suction connections.

Here is the latest product of Worthington research – the new HN line of centrifugal pumps. Designed especially for process industry pumping problems, these heavy-duty pumps can meet all operating conditions up to 850 F and 600 psig.

Versatility. The HN line allows you to choose exactly the right pump. There are three models available: the HN with end suction; the HNT with top suction; and the HNC with integral seal. You have a choice of stock materials of construction – and for those severe corrosive conditions special alloys can be provided. Stuffing boxes are suitable for packing or mechanical seals in full compliance with API specifications.

The integral seal pump gives you all the advantages



SERVICE PROCESS PUMP

of mechanical seal operation and features a totally enclosed seal housing for safe disposal of leakage vapors. Only one size seal is required for all pumps.

The "built-in" versatility of the HN line gives you application flexibility that takes care of changing conditions and cuts operating costs.

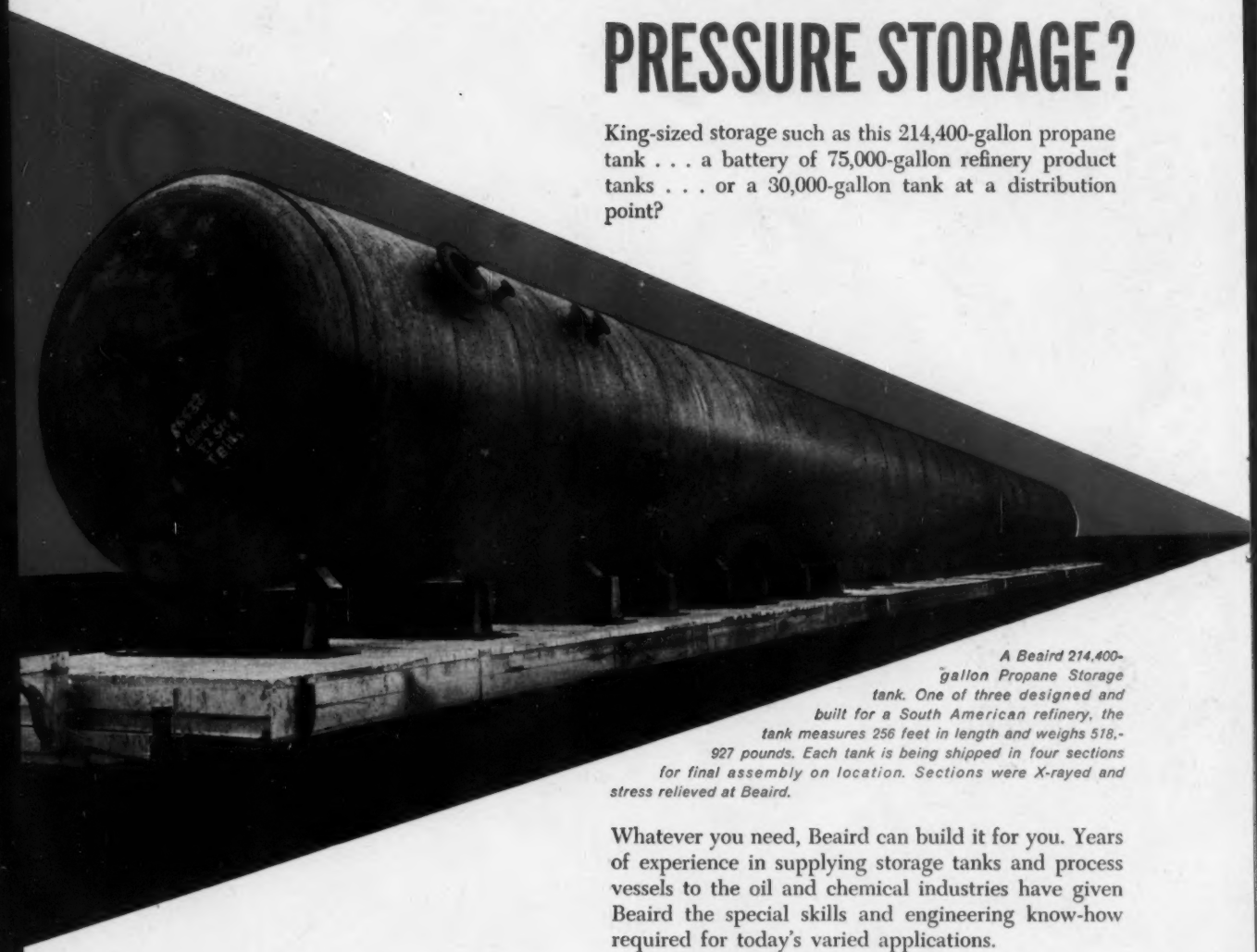
Interchangeability. The entire HN line is built to the same basic design, thereby simplifying maintenance procedure and offering maximum parts interchangeability. Only two bearing assemblies are required for thirteen sizes of pumps. Pumps on the same bearing assembly use identical bearings, shafts, sleeves, and packing or mechanical seals. And end or top suction casings are completely interchangeable.

For more information about the versatile new HN pump, or other units in Worthington's complete line of centrifugal pumps, get in touch with your nearest Worthington District Office. Or write to Section C-74, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Brantford, Ont.

WORTHINGTON

What do YOU need in PRESSURE STORAGE?

King-sized storage such as this 214,400-gallon propane tank . . . a battery of 75,000-gallon refinery product tanks . . . or a 30,000-gallon tank at a distribution point?



A Beaird 214,400-gallon Propane Storage tank. One of three designed and built for a South American refinery, the tank measures 256 feet in length and weighs 518,-927 pounds. Each tank is being shipped in four sections for final assembly on location. Sections were X-rayed and stress relieved at Beaird.

Whatever you need, Beaird can build it for you. Years of experience in supplying storage tanks and process vessels to the oil and chemical industries have given Beaird the special skills and engineering know-how required for today's varied applications.

You benefit as well from Beaird's Quality Control. Modern X-ray equipment, hydrostatic testing, stress relieving facilities, full-time insurance inspectors and strict adherence to fabricating code procedures all play important roles in building Beaird pressure storage.

When your next project is in the idea stage, call in a Beaird sales engineer. His specialized knowledge can help you obtain maximum storage at lowest possible cost.

Over 200,000,000 Gallons Experience

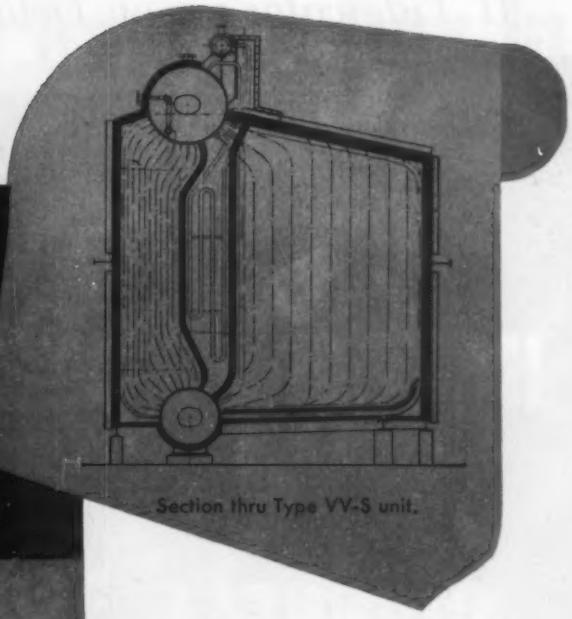
BEAIRD
another AMF product
PRESSURE STORAGE VESSELS

THE J. B. BEAIRD COMPANY, INC.
A Subsidiary of American Machine & Foundry
Shreveport, La. • Stockton, Calif. • Clinton, Iowa

For more data on advertised products, use Readers' Service Cards, last page.

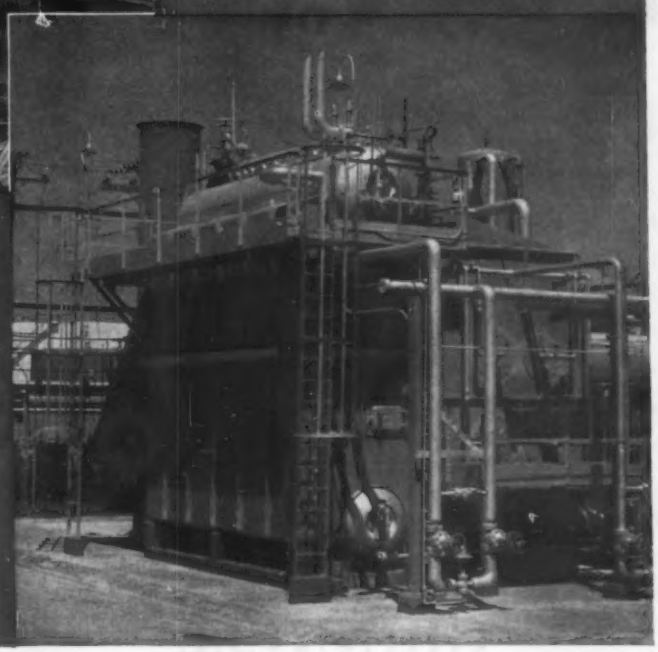
More Steam with Fewer Dollars

Vogt TYPE VV-S STEAM GENERATORS



Section thru Type VV-S unit.

Two 50,000 #/hr. units under erection at an Air Force Base.



A 65,000 #/hr. unit in a Texas Petroleum Refinery

- ★ Headerless construction for full unrestricted water circulation.
- ★ Large water storage capacity and correspondingly greater steam relieving space.
- ★ Long, narrow furnace ideal for oil or gas fuel.
- ★ Completely steel encased for "out-in-the-open" operation.
- ★ Simple slab foundation.
- ★ Capacities from 50,000 pounds to 100,000 pounds steam per hour.

OTHER VOGT PRODUCTS

Drop Forged Steel Valves, Fittings and Flanges—
Petroleum Refinery and Chemical Plant Equipment
Heat Exchangers
Ice Making and Refrigerating Equipment

HENRY VOGT MACHINE CO.

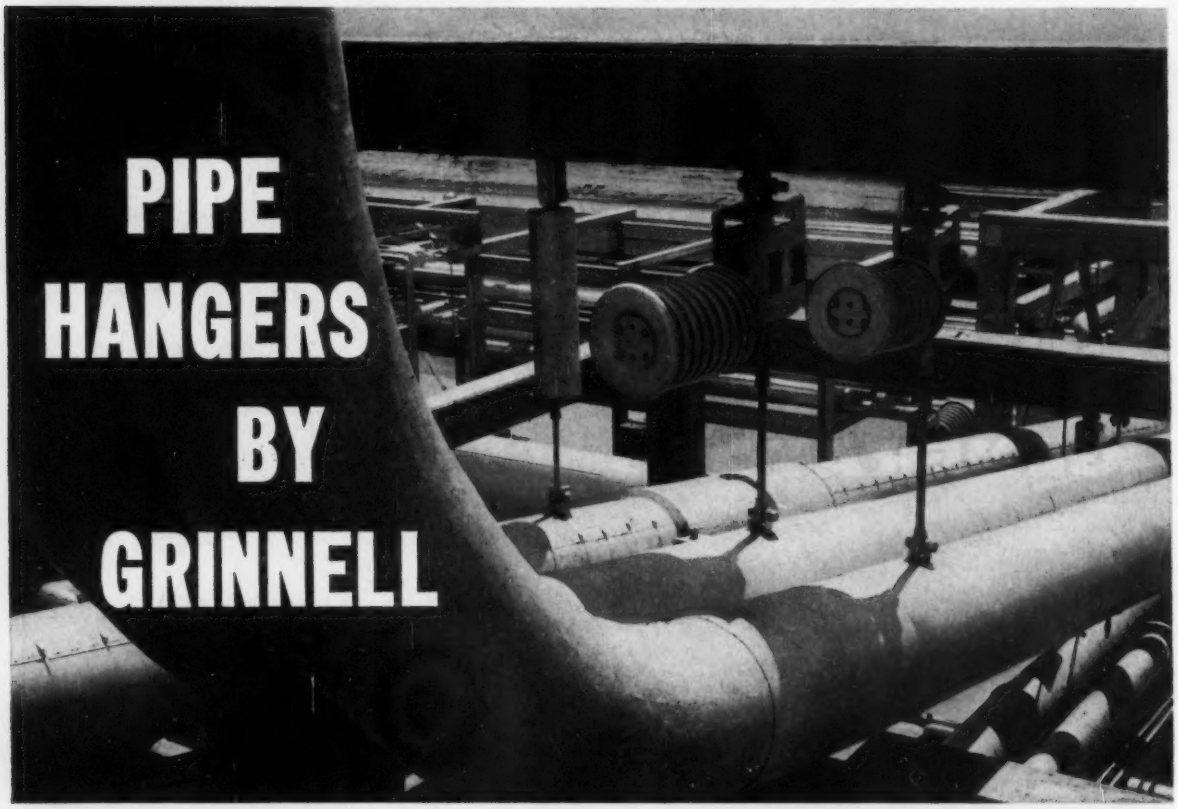
Box 1918, Louisville 1, Kentucky

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va., Cincinnati

For more data on advertised products, use Readers' Service Cards, last page.

At Tidewater's new Delaware Refinery...

PIPE HANGERS BY GRINNELL



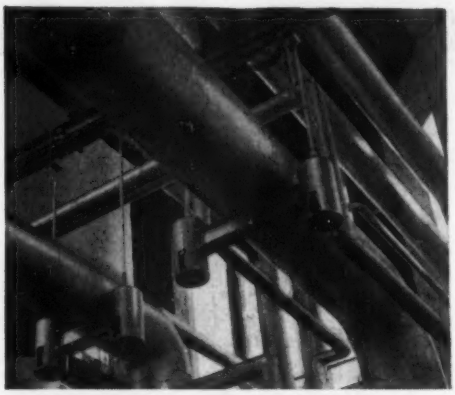
Tidewater Oil Company's new ultramodern $200-million, 5000-acre refinery, south of Wilmington, is the largest ever constructed at one time. Capable of processing 130,000 barrels of crude oil daily, the Delaware Refinery boasts eleven major processing units, including six of world-record size.

Pipe suspension problems, too, were bigger and more challenging at this record-breaking refinery. That's why Tidewater turned to Grinnell, America's #1 supplier of pipe hangers and supports.

A volume producer of pipe hangers, Grinnell backs up its high capacity and diversification with an efficient coast-to-coast network of warehouses and jobbers. Even complex hanger requirements very often can be met with hanger assemblies right off the shelf. This not only saves you time, but it can save you money, by cutting down on the number of special items which must be manufactured.

If you have a pipe suspension problem, you are invited to write: Grinnell Company, Inc., 282 West Exchange St., Providence, Rhode Island.

GRINNELL CONSTANT-SUPPORT HANGERS are engineered to maintain full safety factor. Constancy of support is mathematically perfect for all positions of travel. Note low headroom requirement. Load ranges from 30 lbs. to 32,260 lbs., with travels up to 12 inches.



GRINNELL VARIABLE SPRING HANGERS have precompression feature which assures operation of spring within its proper working range. Maximum variation in supporting force per ½" of deflection is 10½% of rated capacity — in all sizes. Available in 21 sizes for loads ranging from 50 lbs. to 28,200 lbs.

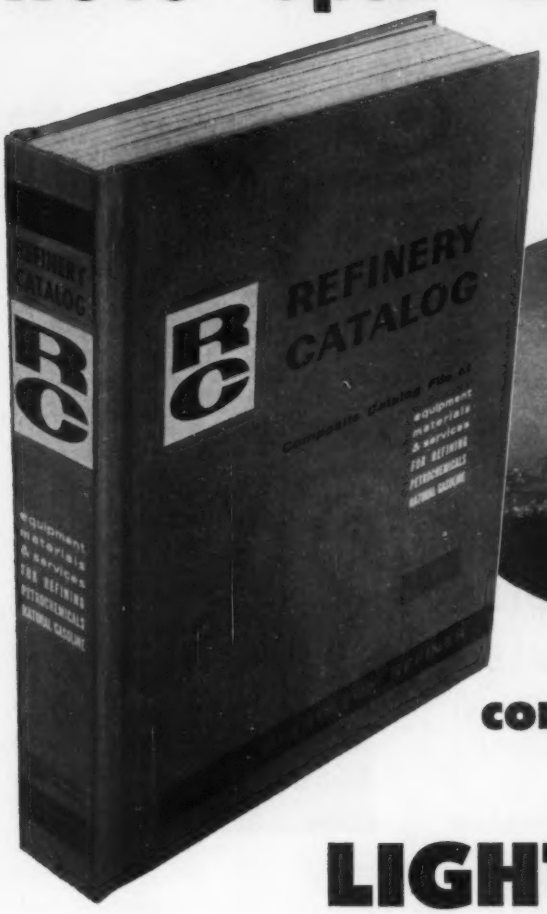
GRINNELL

AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic fire protection systems • Amco air conditioning systems

We're "Open" 24 Hours a Day in



REFINERY CATALOG

complete, quick reference information on

LIGHTNIN Mixtures

The pages of REFINERY CATALOG are never closed . . . bringing you around the clock information on products and services. Because we know you prefer such a single-source reference, we have selected this Catalog to carry our catalog data to more than 8,500 buyers and specifiers in the refining, petrochemical and natural gasoline industry throughout the world. We believe this pre-filed data will be of time-saving value and convenience to you.

When you want quick facts on fluid mixing, turn to the catalog data in Refinery Catalog. There you'll find condensed catalog information on LIGHTNIN Mixers for any type of service. The LIGHTNIN catalog unit is made up of 16 fact-filled pages on mixer construction, impeller selection, scale-up, and mixer efficiency. If you can't find all the information you need, check the list of LIGHTNIN sales representatives and call the nearest one.

MIXING EQUIPMENT Co., Inc. 135 Mt. Read Blvd., Rochester 11, N.Y.

IN CANADA: Greey Mixing Equipment Ltd., 100 Miranda Ave., Toronto 10, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

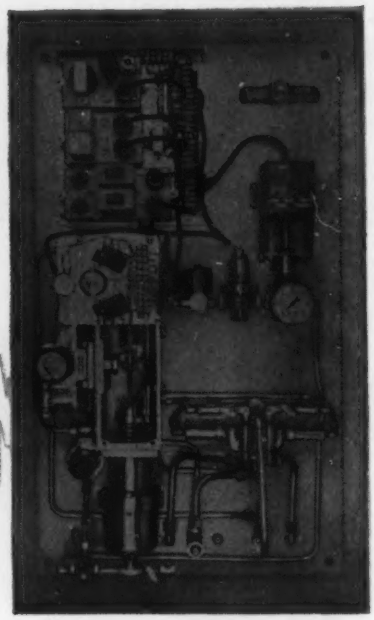
NOW! Cash Standard-Sparton brings you the World's First

Packaged Remote Control System

regulates final control elements governing

- **PRESSURE**
- **FLOW**
- **SURGE**
- **PROPORTIONING**
- **LIQUID LEVEL**
- **SPEED**

and other process variables



SUPERVISORY CONTROL UNIT

For remote location at distances of a few feet to many miles. Operates on telephone, telegraph, private lines or microwave.

Now—for the first time in a single package system—it is possible to control, from a distance of many miles if necessary, the positioning of cone, butterfly, plug and ball valves; sliding stem valves; throttles, rheostats and other variable speed mechanisms; and similar final control elements.

The unique Series 300 Packaged Control System, developed by A. W. Cash Company and Sparton Corporation, reduces operating costs substantially through regulation of final control elements by one operator from one central point. As a result, the equipment pays for itself rapidly. It is recommended particularly for such applications as pipe lines, pumping stations, oil wells, storage tanks, power stations, municipal water distribution, petroleum and chemical processing and atomic energy processing.

For complete information on the remarkable new Cash Standard-Sparton Series 300 Packaged Control System, see the Cash Standard control specialist in your area, or write to Dept. L.

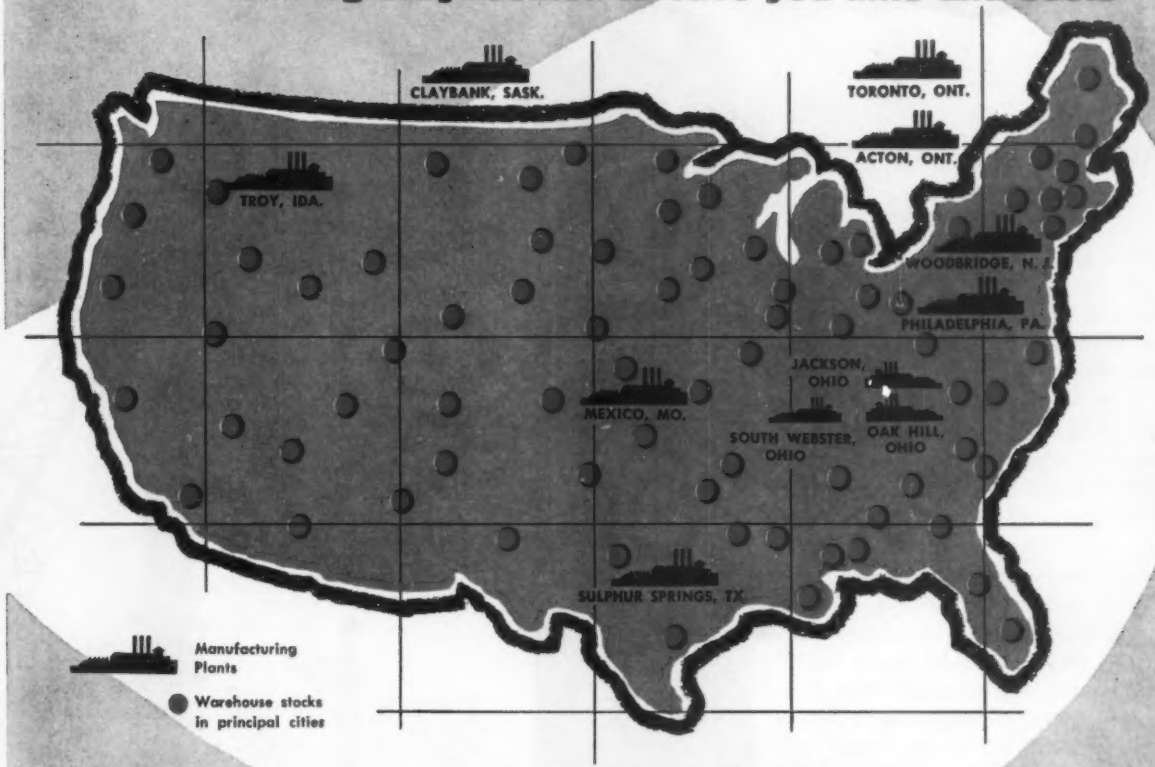
CASH CS STANDARD

A. W. Cash Co. and Its Subsidiary, Cash Standard Stacon Corp.
P. O. Box 551, Decatur, Ill.

Pressure, Hydraulic, Temperature, Process and Combustion Controls

A. P. Green
REFRACTORY PRODUCTS

manufacturing and warehouse facilities strategically located to save you time and costs



11 A. P. Green manufacturing plants and warehouse stocks conveniently located throughout the United States and Canada, Save You Money 7 Ways.

- **Lower Shipping Costs . . . from nearby manufacturing or warehouse point.**
- **Lower Capital Investment . . . your capital is not tied up in warehouse space.**
- **Lower Inventory Costs . . . you need inventory only for *immediate* needs.**
- **Lower Inventory Losses . . . buy on current prices . . . less breakage while in storage.**
- **Increase Production Space . . . free storage space for profitable production.**
- **Lower Labor Costs . . . deliveries to point of usage . . . no inplant moving of stocks.**
- **Maintain Steady Production . . . reduce down time waiting for materials.**

Your A. P. Green Distributor is Listed In The Yellow Pages of Your Telephone Directory, or write:

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

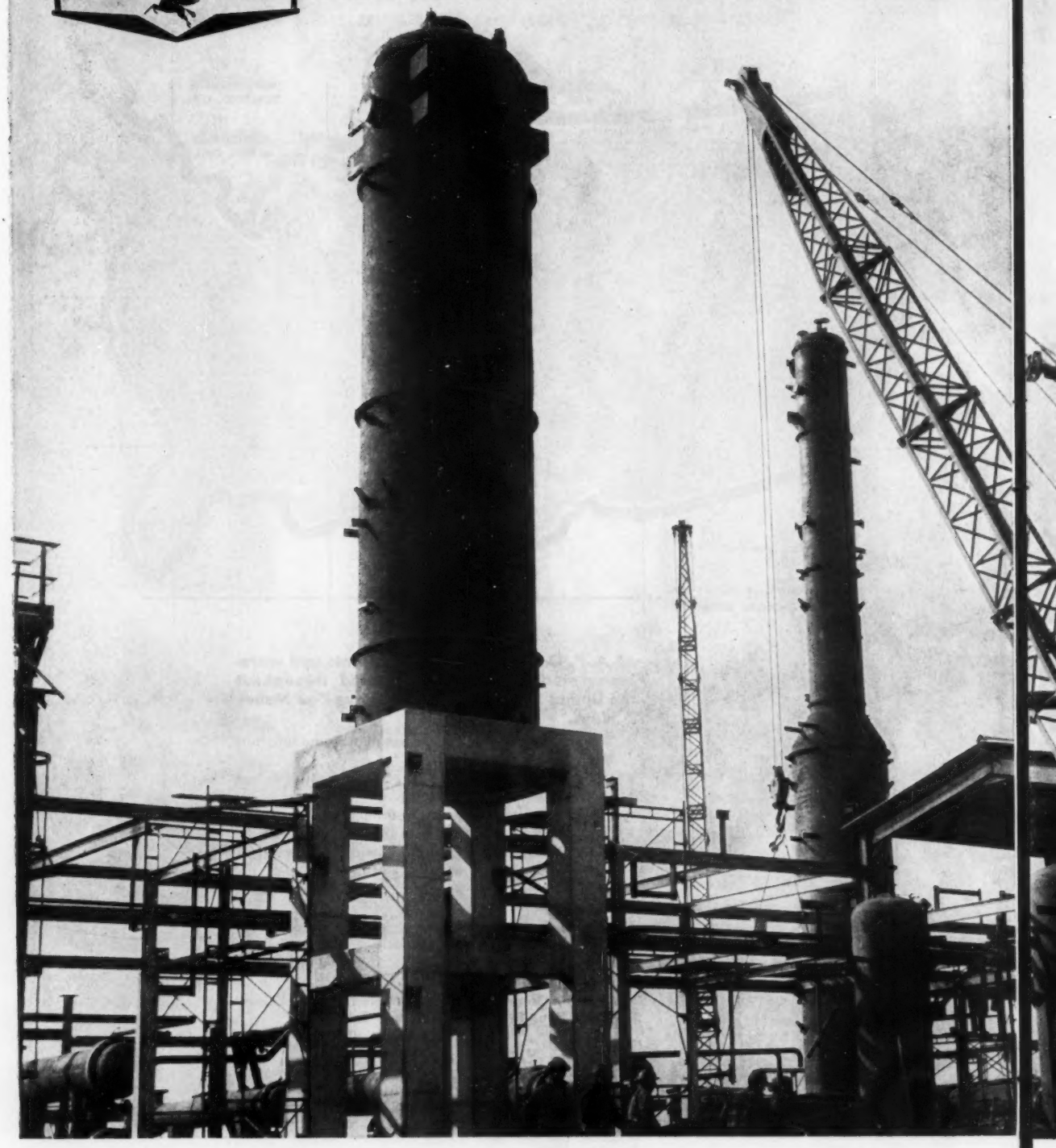
PLANTS:
Mexico, Mo. — Woodbridge, N. J. — Sulphur Springs, Texas — Jackson, Oak Hill, South Webster, Ohio — Philadelphia, Pa. — Troy, Idaho.

IN CANADA:
A. P. Green Fire Brick Company, Ltd., Toronto 15, Ontario

Distributors In The Principal Cities of The World

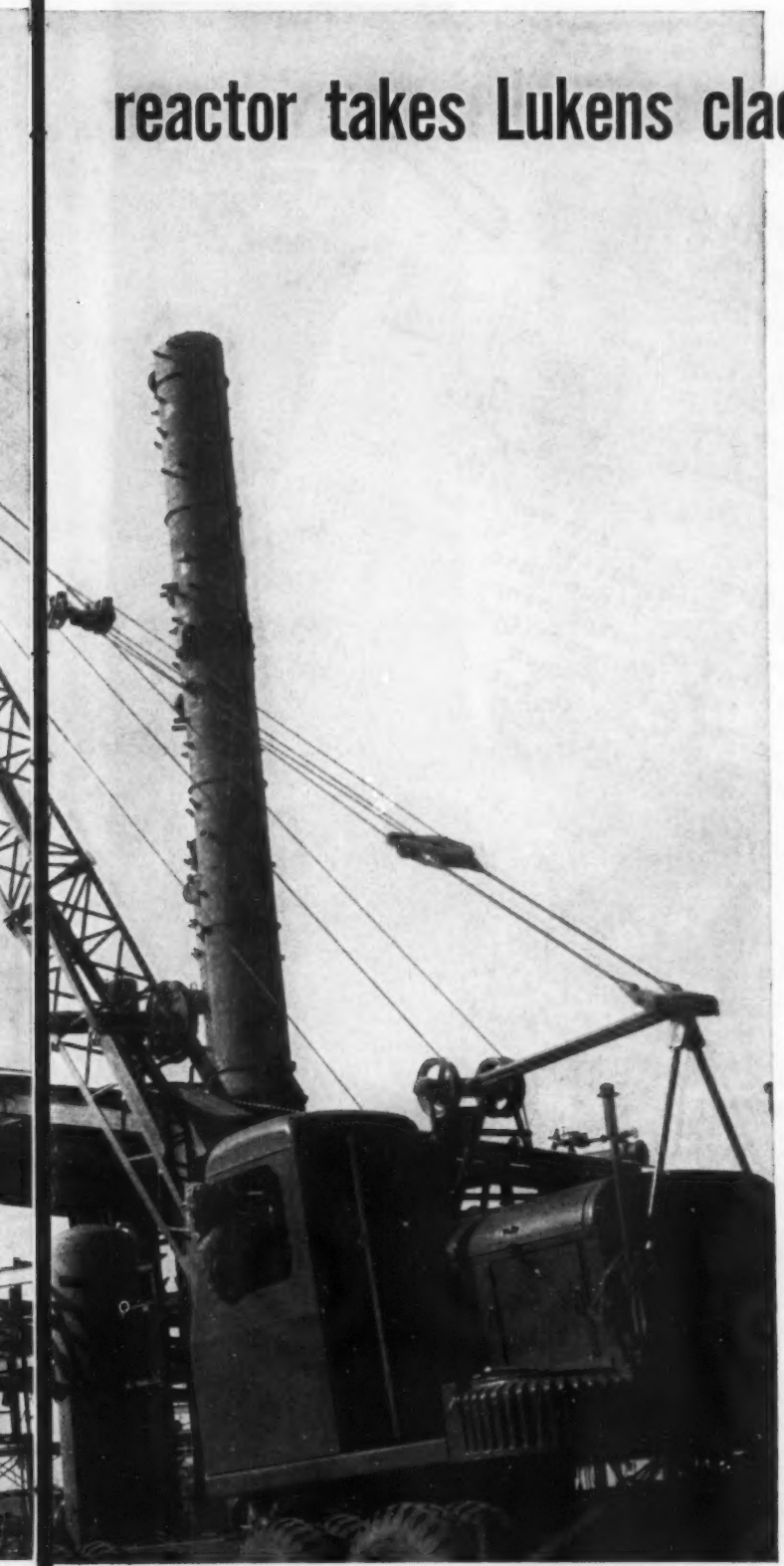
Mobil

Catalytic hydrodesulfurization



This is Lukens clad steel—not a lining, not a soldered-on surface, but a solid plate—one side corrosion resistant metal permanently bonded over-all to a rugged, economical backing steel.

reactor takes Lukens clad and alloy steels



CLAD STEEL STRIPPER, FLASH DRUM ALSO INSURE LONG-RUN ECONOMY, FREEDOM FROM MAINTENANCE

Designers and fabricators for Socony Mobil selected Lukens clad steel to combat corrosion by sulfur compounds . . . even at peak temperatures and pressures at which its new 22,000 bbl. catalytic hydrodesulfurization unit will operate at Paulsboro, N. J.

For the reactor vessel (left) and the top nine feet of the product stripper, Lukens stainless-clad type 321 was specified. ASME heads by Lukens are of the same materials —as is the flash drum.

Of equal importance, the backing of Lukens alloy—A-204 Gr. B carbon moly—resists the creep and hydrogen embrittlement which might otherwise result in this service. Typical temperatures range from 400° to 850°F., at pressures from 50 to 1500 psig. The installation is the first of many which Socony Mobil is planning for making No. 2 fuel oil a more efficient, better burning product.

It is another example of how Lukens clad and alloy steels provide maintenance-free corrosion protection at high temperatures and pressures.

Ask your equipment builders, or write for the new **Clad Steel Equipment** bulletin, as well as information on alloy steels. Address Manager, Marketing Service, Room 968, Lukens Steel Company, Coatesville, Pa.

LUKENS ®

Helping industry choose steels that fit the job

For more data on advertised products, use Readers' Service Cards, last page.

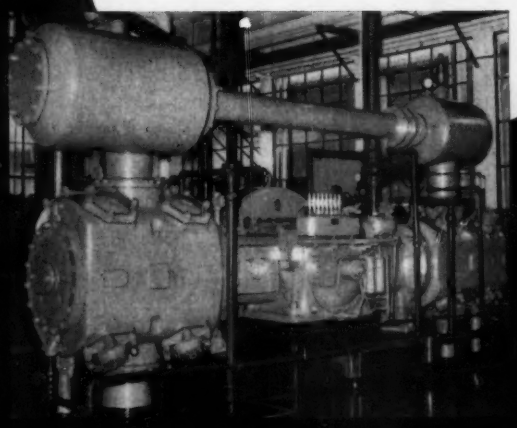
Gene:
Here's another excellent customer report of Cooper-Bessemer compressor performance
Mike

*Excerpt from a letter written by the Plant Engineer of one of Firestone's foreign subsidiaries.

*This is one piece of equipment we are very happy to recommend to all prospective customers of Cooper-Bessemer. Since this unit was installed, it has operated over 13,800 hours, 6 days a week, 24 hours per day without down time for maintenance. It has given continuous service at rated capacity with no production stoppage or material spoilage.

Very truly yours,

Plant Engineer



Cooper-Bessemer motor-driven EM compressor in a tire manufacturing plant of The Firestone Tire and Rubber Company. This heavy-duty unit, rated 200 hp at 450 rpm, efficiently handles the compression of air from atmosphere to 100 psig.

BRANCH OFFICES: Grove City • New York
Chicago • Washington • San Francisco • Los Angeles
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SUBSIDIARIES: Cooper-Bessemer of Canada, Limited . . . Edmonton • Calgary • Halifax.
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Cooper Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS · DIESEL · GAS DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE OR MOTOR DRIVEN

IN PETROLEUM ...from wells to wings!

BASIC CHEMICALS ...from GENERAL CHEMICAL

At practically every stage of petroleum production and processing, you will find need for basic chemicals from General Chemical . . . a supplier you can count on for prompt delivery of these key process materials, that meet your exact requirements:

ALKYLATION
Anhydrous Hydrofluoric Acid
Sulfuric Acid

POLYMERIZATION
Fluosulfonic Acid $HO:SO_2F$
Boron Trifluoride
Sulfuric Acid

SULFONATION
Sulfuric Acid
Sulfan® (Stabilized Sulfuric Anhydride)
Oleum

ISOMERIZATION
Hydrochloric (Muriatic) Acid

DETERGENTS, CLEANERS & BUILDERS
Sodium Metasilicate
Disodium Phosphate
Sodium Sulfate, Anhydrous
Trisodium Phosphate
Tetrasodium Pyrophosphate (TSPP)
Sodium Tripolyphosphate

ACIDIZING
Hydrochloric (Muriatic) Acid
Hydrofluoric Acid
Sodium Bifluoride

MUD CONDITIONING
Sodium Silicate
Disodium Phosphate
Trisodium Phosphate
Tetrasodium Pyrophosphate (TSPP)
Sodium Tripolyphosphate

GREASE MAKING
Aluminum Sulfate

ACID TREATING
Sulfuric Acid
Sodium Silicate

Other Heavy Chemicals, catalysts, addition agents, inhibitors and special "tailor-made" chemicals.

Baker & Adamson®
Laboratory Reagents

GENERAL CHEMICAL DIVISION
ALLIED CHEMICAL & DYE CORPORATION

40 Rector Street, New York 6, N. Y.

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GC Allied Chemical

Basic Chemicals for American Industry

STAYNEW

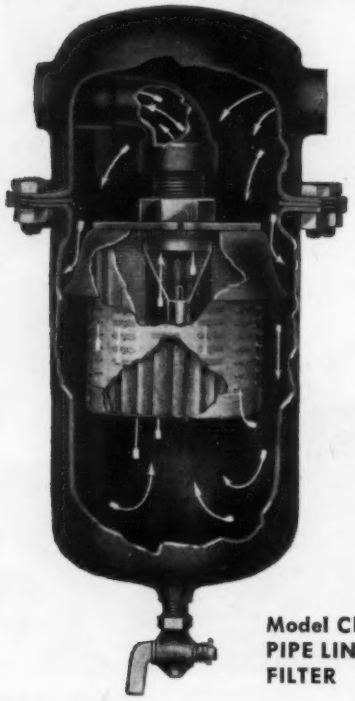
PIPE LINE FILTERS

FOR

CLEAN DRY AIR

IN

- AIR OPERATED INSTRUMENTS
- AIR OPERATED TOOLS
- PNEUMATIC CONTROLS
- INDUSTRIAL PROCESSES



Model CPH PIPE LINE FILTER

MODEL CPH PIPE LINE FILTER has exclusive Staynew "double action principle." Air is first deflected to outer walls of filter and forced downward at high speed. Water, oil and heavier particles of rust, etc., are thus deposited in base. Mechanically cleaned air then rises to pass through filtering medium which removes lighter airborne particles. This double action design eliminates need for frequent cleaning.

Inexpensive, simple to install and maintain, Staynew Pipe Line Filters keep your air-operated equipment free from the destructive effects of pipe scale, dust, dirt, and condensates. And, Staynew Filters pay for themselves in reduced equipment maintenance costs alone. They filter compressed air under all pressures and temperatures, natural and manufactured gases. Dollinger engineers will welcome your filtration problems. Why not call on us. Remember, Dollinger *makes* every type of filter for every industrial need.

INTAKE FILTERS

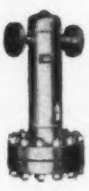
LIQUID FILTERS

PIPE LINE FILTERS

ELECTRO-STAYNEW PRECIPITATOR

AUTOMATIC AIR FILTERS

PANEL FILTERS



SPECIAL FILTERS

Write for Bulletin 200 which contains complete engineering data and illustrated material on Staynew Pipe Line Filters. Dollinger Corporation, Dept. 47, Centre Park, Rochester 3, N.Y.

PROTECTOMOTOR U.S. PAT. OFF.

STAYNEW **DOLLINGER**

FILTERS

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

For more data on advertised products, use Readers' Service Cards, last page.

This 150-Foot Hose
STRETCHES AROUND THE WORLD

Refueling-in-air techniques such as these now make possible non-stop trips around the world. But no matter where the refueling takes place, the pipeline begins at the nation's refineries.

With experts predicting that by 1965 refined product sales will have increased 2½ times over 1946, the need for efficient refinery operations is obvious. Perhaps Polyrad—the filming amine inhibitor and detergent—can play a role in your operation.

Polyrad forms a molecular film that protects metal from attack and reduces down time caused by corrosive damage. Polyrad's detergent action keeps metal surfaces clean to maintain heat transfer and operation at unit capacity.

A Hercules trained representative will be glad to tell you how Polyrad can protect your refinery. Stocks are maintained at strategic points throughout the country and overseas.

Pine Chemicals Division, Naval Stores Department

HERCULES POWDER COMPANY
INCORPORATED

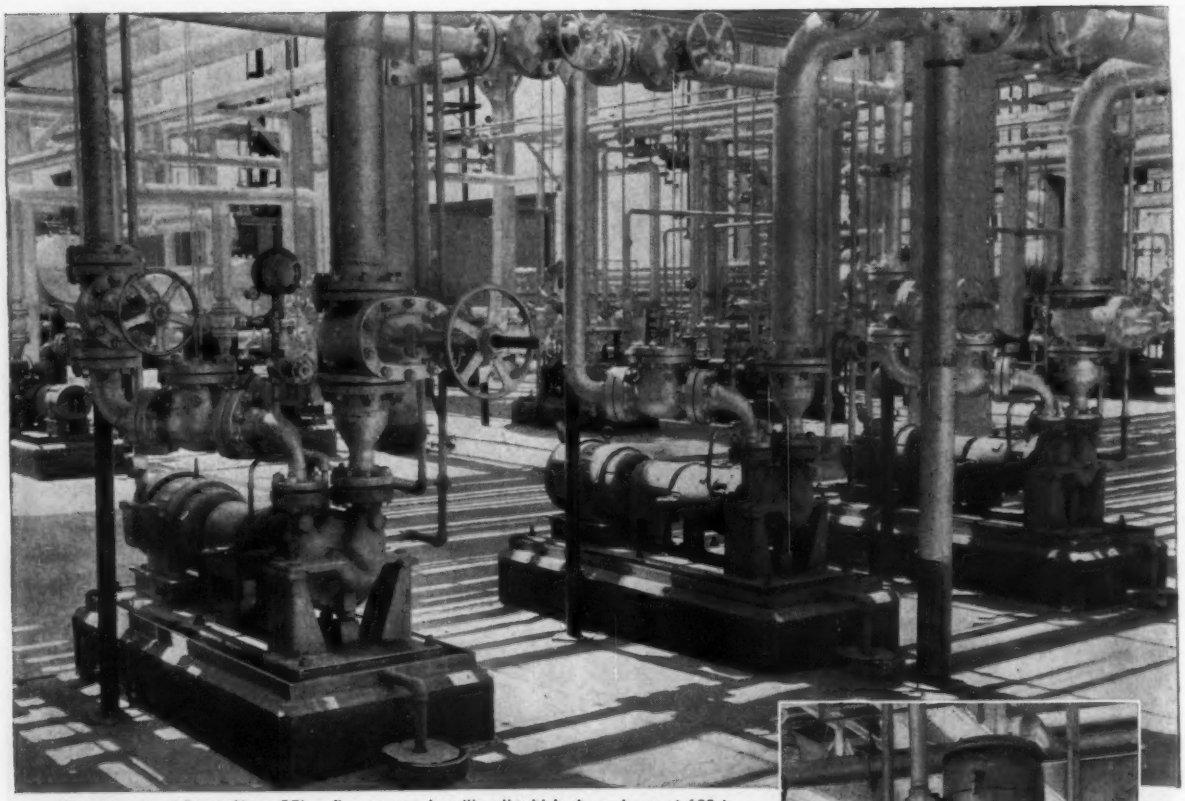
900 Market St., Wilmington 99, Del.

REFINERS RELY ON

POLYRAD®

FILMING AMINE INHIBITOR NA57-2

For more data on advertised products, use Readers' Service Cards, last page.



Three Ingersoll-Rand Class SFL reflux pumps handling liquid hydrocarbons at 100 to 110 gpm for new reforming unit at Cosden refinery.

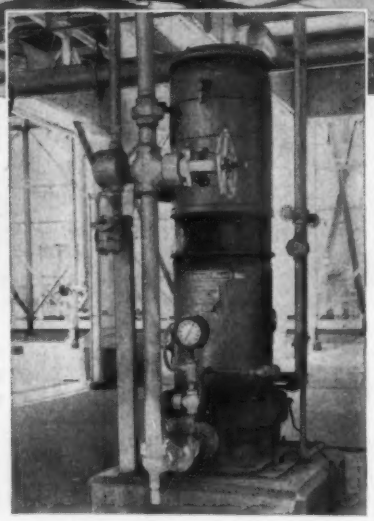
REFLUX PUMPS

at Cosden Rexformer Unit

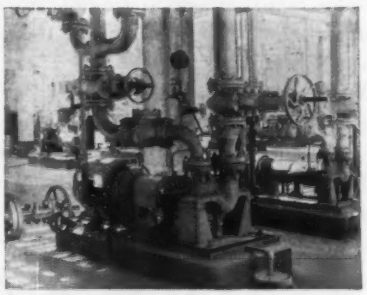
Ingersoll-Rand Centrifugals handle "vital fluids" for new Rexformer Unit at large Texas refinery

HERE AT the Big Spring Refinery of Cosden Petroleum Corporation, thirty Ingersoll-Rand centrifugals have the important job of pumping the "life blood" for the new U.O.P. designed Rexforming Unit. In addition to the reflux pumps shown here, other I-R pumps are in circulating, transfer and charge service — all performing functions vital to sustained operation of the reforming process.

Here at Cosden — as in major refining and processing plants all over the world — the dependability, efficiency and low maintenance of Ingersoll-Rand pumps contribute to the economy and trouble-free performance of the entire plant. For a *fast solution* to your pumping problems, just call your nearest I-R Branch Office.



Ingersoll-Rand 25-hp Class VP vertical extraction reflux pump handling hydrocarbon stock at 55 gpm.



Two Ingersoll-Rand Class MFL stripper column reflux pumps, each rated 390 gpm.

Ingersoll-Rand

10-691 11 Broadway, New York 4, N. Y.

PUMPS • COMPRESSORS • DIESEL ENGINES • AIR & ELECTRIC TOOLS • TURBO BLOWERS • CONDENSERS

Now every laboratory can afford a precision mass spectrometer

High sensitivity at low cost for plant, field, and laboratory

Now you can improve your process control or analytical service with an inexpensive, portable mass spectrometer. CEC's completely new 21-611 adapts easily to installation in a trailer, on a bench—wherever there is space for the 115-lb unit. The instrument covers mass range 2 through 80, with automatic scanning from mass 12 to 40 requiring only 3 minutes. Extremely rugged and simple to operate, the 21-611 consists of separate electronic and vacuum modules which may be operated stacked or apart. Ingenious design for trouble-free operation has eliminated the conventional cold trap, one forepump, magnet shunt, and several vacuum tubes. Investigate this outstanding value by calling your nearby CEC field office, or write for Bulletin CEC 1843-X4.

Capable of analyzing minute samples of gases, gaseous mixtures, or vaporized liquids with precise accuracy, the economical 21-611 offers automatic programming of control mechanisms and a unique scanning dial which eliminates mass marking. Complicated sample introduction procedures are unnecessary with the simplified batch inlet system featuring a single all-metal rotary valve. Entire portable unit weighs only 115 pounds.

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

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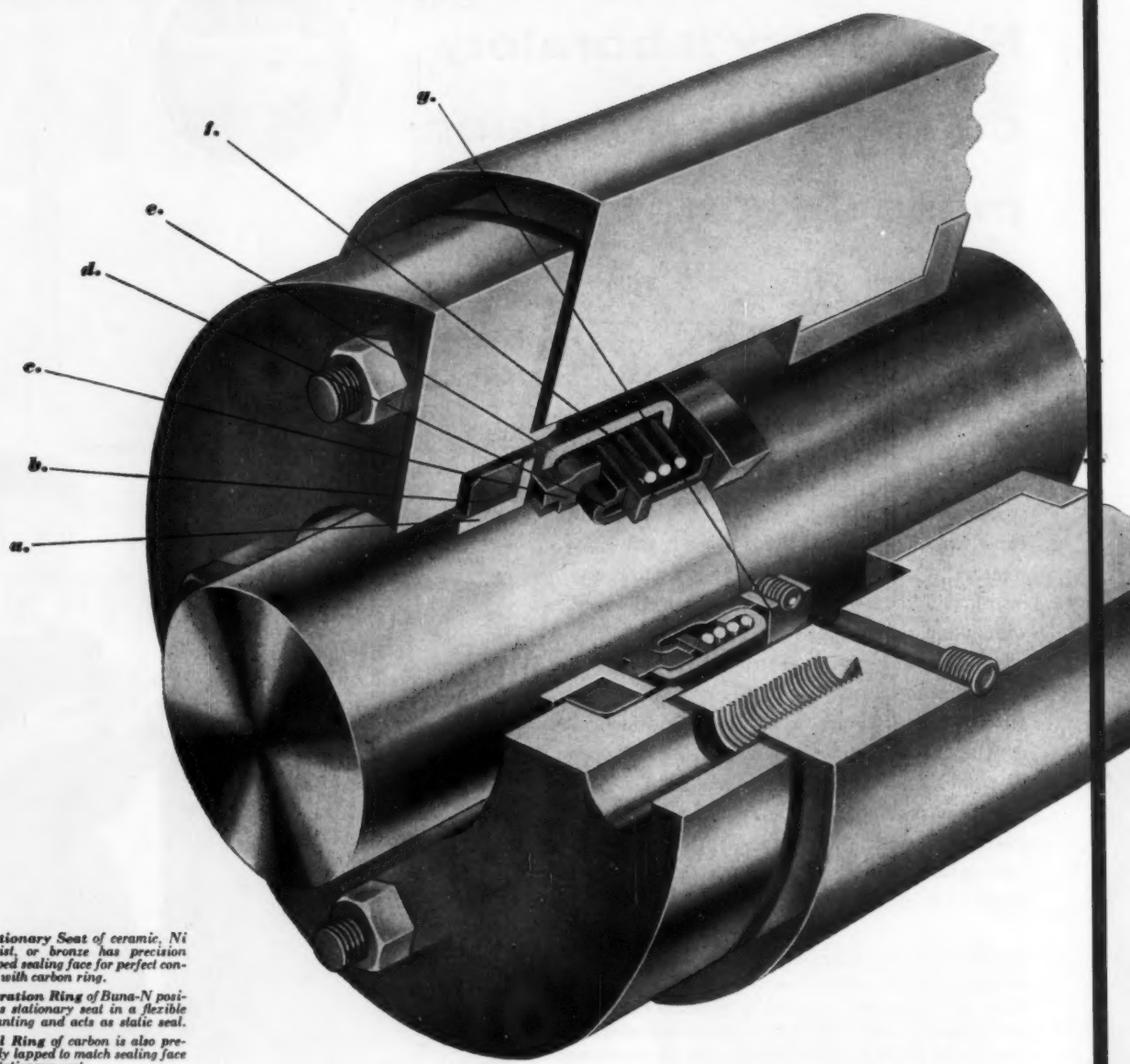
MORE OF THE GARLOCK **2,000**

No More Stuffing Box Maintenance!



a. ***Stationary Seat*** *of ceramic, Ni Resist, or bronze has precision lapped sealing face for perfect contact with carbon ring.*

b. ***Vibration Ring*** *of Buna-N positions stationary seat in a flexible mounting and acts as static seal.*

c. ***Seal Ring*** *of carbon is also precisely lapped to match sealing face of stationary seal.*

d. ***Roll type Bellows*** *permits free movement of seal ring.*

e. ***Shell,*** *encases entire rotary unit and furnishes mechanical drive for seal ring.*

f. ***Stainless Steel Spring*** *with load precisely calculated to face area of seal.*

g. ***Stop Collar,*** *or shoulder, positions seal to specified operating length.*

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

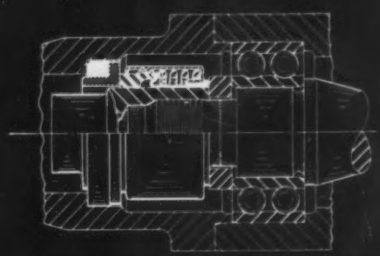
Install Garlock Package Seals on Your Present Pumps

- *ELIMINATE LEAKAGE AND SHAFT WEAR*
- *REDUCE DOWNTIME*
- *CUT MAINTENANCE COSTS*

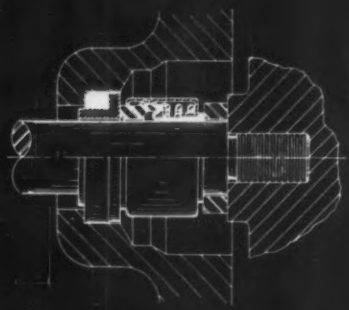
When leakage and maintenance are serious problems in the operation of your pumps you'll find a perfect answer in Garlock MECHANIPAK* Seals. Installation on new or existing equipment is simple. And, several designs are available to meet a variety of operating conditions: pressures to 150 psi, temperatures to 212° F., and shaft speeds to 2000 feet per minute. Sizes for shafts from ⅜" to 3" diameter for sealing against water, oils, alcohol, mild acids and solvents.

MECHANIPAK Seals are another important part of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets and seals for every need. It's the only complete line . . . that's why you get unbiased recommendations from your Garlock representative. Ask him for complete data on this long-life, maintenance-free MECHANIPAK Seal. Or write for Folder AD-150.

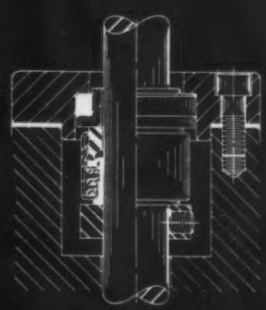
*Registered Trade Mark



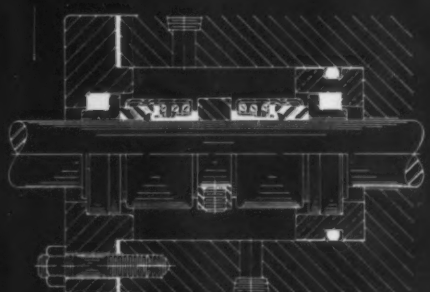
MECHANIPAK Package Seal installed on shaft for retaining lubricant in bearing.



MECHANIPAK Package Seal installed against impeller of centrifugal pump.



Package Seal installed on vertical pump shaft.



Double Package Seal installation on horizontal agitator shaft.

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products

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AMOCO CHEMICALS—A NEW RESOURCE

for petroleum additives
for petroleum additives research, testing and technical service

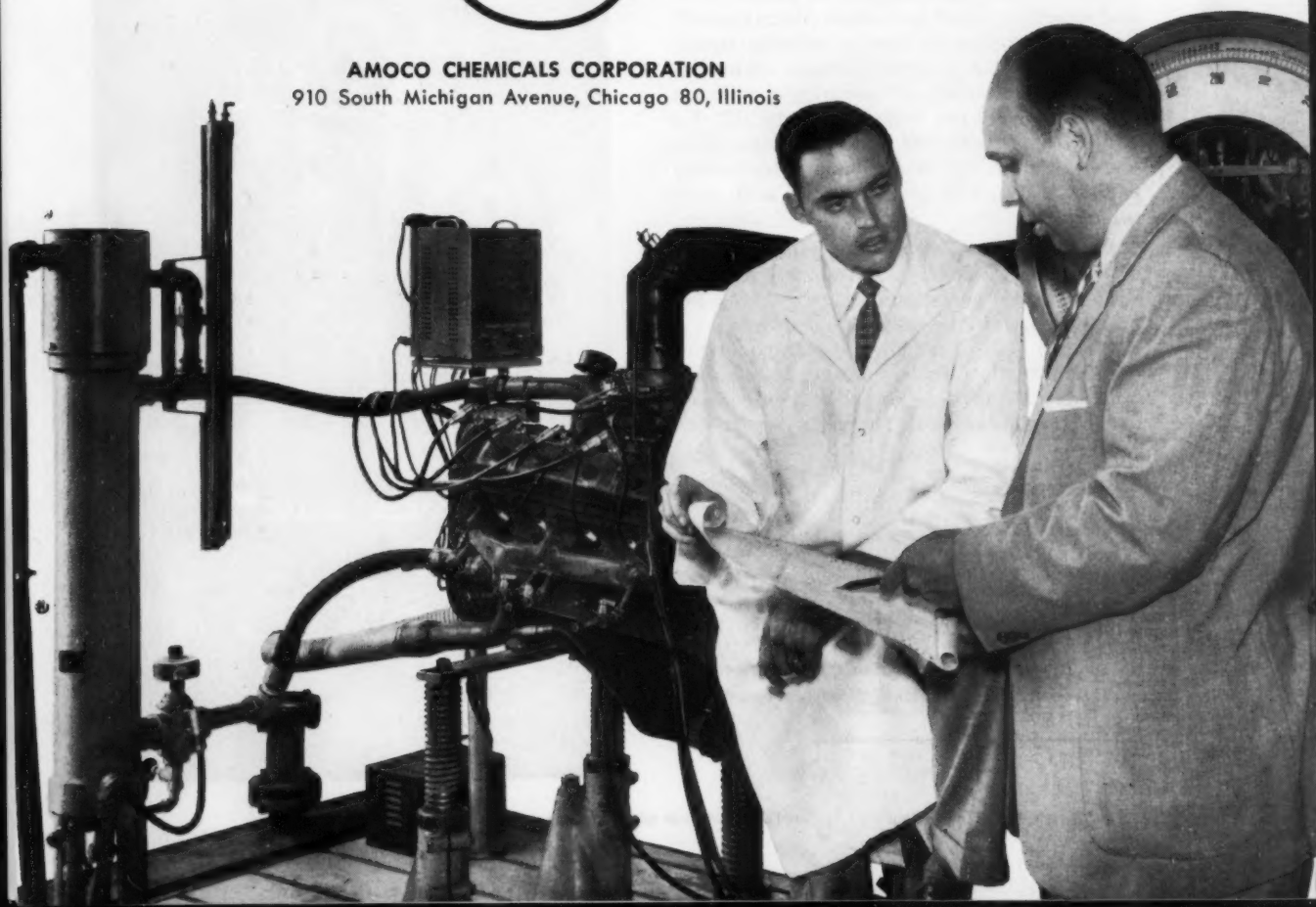
AMOCO Chemicals Corporation is a new resource for petroleum additives. This new resource is implemented by: (1) extensive research facilities for the development of improved additive chemicals, (2) engine test laboratories to help evaluate the performance of your motor oils, (3) men fully qualified through experience to cooperate with you in laboratory and field test programs.

AMOCO Chemicals sales engineers have had years of experience in the proper application of petroleum additives. They are ready to assist you in formulating motor oils to meet the requirements you have established for your products.

Want more information about the petroleum additives research, test or technical service facilities of AMOCO Chemicals? Your request for additional information will receive immediate attention.

AMOCO
CHEMICALS

AMOCO CHEMICALS CORPORATION
910 South Michigan Avenue, Chicago 80, Illinois



NEW! direct tank-mounted LIQUID LEVEL TRANSMITTER

Exclusive static pressure connection for closed vessels above or below atmosphere . . . eliminates need for second instrument.

This sensing diaphragm capsule flange-mounts directly on side of tank. All wetted parts of Type 316 stainless steel, with optional plastic coating for further corrosion protection.

with DIRECT 3-15 psi air output signal

IDEAL FOR: Viscous or corrosive fluids, slurries, and solids-in-suspension, as well as "easy-to-measure" fluids.

Now you can measure the level of "difficult" or easy-to-measure fluids — economically, without the complication of floats or bubble tubes, and with *sustained high accuracy over the entire range span.*

Flange-mounted directly to the side of an open or closed tank, the Type 13FA Transmitter eliminates piping and purging. Its stainless steel diaphragm capsule senses level changes instantly. Conventional tubing leads its output air signal directly to standard 3-15 psi receiver-recorders and controllers without need for intermediate signal converters.

The 13FA provides an accurate, trouble-free solution for level measurement problems. Write for detailed information, or ask your nearby Foxboro Field Engineer to explain its application to your specific process. **The Foxboro Company, 7410 Norfolk St., Foxboro, Mass., U.S.A.**

FOXBORO
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LIQUID LEVEL TRANSMITTERS

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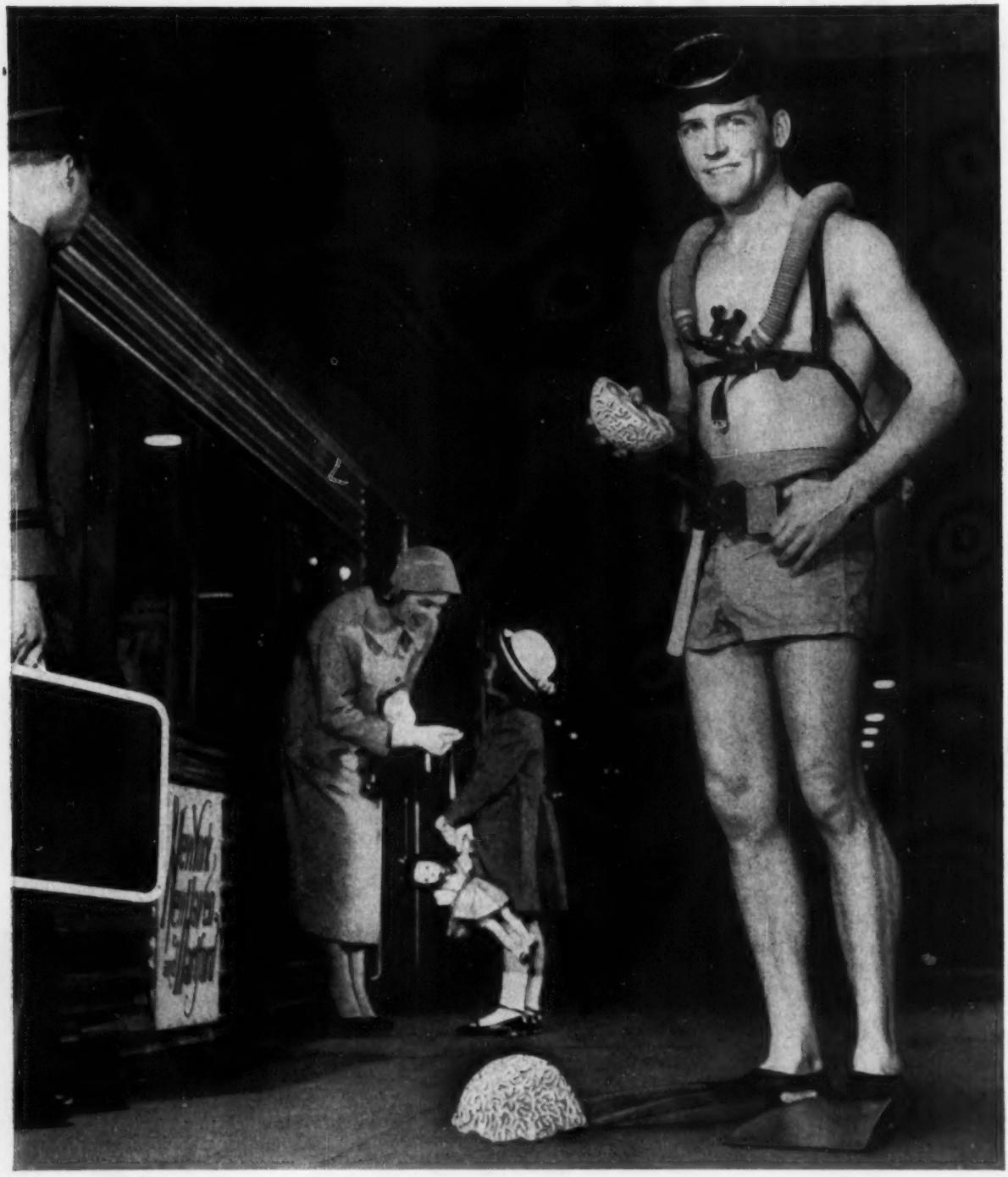
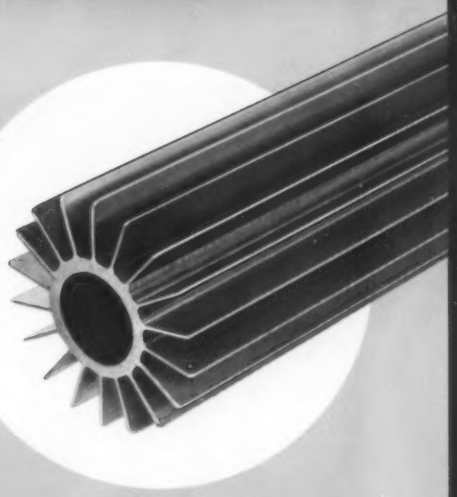


Make room for oilmen on the Limited. Our seagoing geologist doesn't usually travel with his coral samples. But they're clues in the search for oil, and he's making the point that oilmen help railroads carry people and freight from here to almost anywhere. The latest count tallied 440 million passengers and 2.5 billion tons of freight in one year. So if your seat mate on the train doesn't know the facts and talks against the oil industry, tell him you're an oilman and proud of it. And tell him why. **SHELL OIL COMPANY**

There is one type of

HEAT TRANSFER SURFACE

best suited to your next heat exchanger.

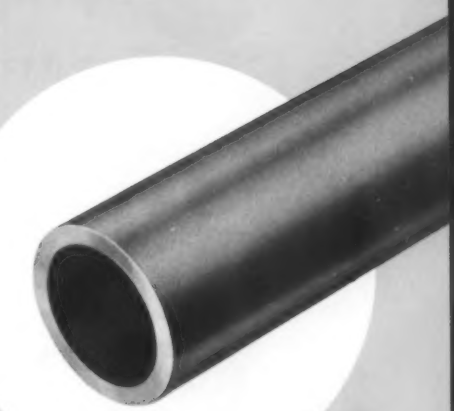


G-R can impartially and authoritatively tell you which

In some cases, *bare tubes* may be the most practical type of heat transfer surface for your needs. In other cases, *finned tubes* may provide a more efficient and compact exchanger.

G-R builds heat transfer apparatus with *either* bare tubes or finned tubes. G-R finned tube surfaces include both longitudinal G-Fin and helical K-Fin . . . two widely popular types that have proved their superiority in hundreds of thousands of installations throughout the world.

G-R builds both shell-and-tube units and open sections . . . for large or small capacities . . . for high or low temperatures and pressures . . . for clean or clogging fluids, with high or low heat transfer rates. Your problem involves some of these conditions. G-R engineers have met all these conditions in all of their combinations. Let us advise you. Call in a G-R representative today.



THE GRISCOM-RUSSELL CO.

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

MASSILLON, OHIO

HERE'S AN EXAMPLE OF G-R LEADERSHIP IN HEAT TRANSFER APPARATUS

Griscom-Russell is now entering the last decade of a

Century of Progress

Looking Backward

Ninety years ago in New York Harbor a modest ship chandlery was established to service the needs of seagoing vessels as they plied into port for fitting and repairs. The enterprise developed fast until it was manufacturing small equipment and later a line of coil tube heat exchangers, which due to their long, efficient and trouble free service, created the reputation for dependable products which The Griscom-Russell Company still enjoys. There followed equally reliable lines of Marine Distilling Plants, Tubular Exchangers, Bentube Evaporators, Feedwater Heaters and Extended Surface Heat Exchangers for land and sea service. Through the years the chemical, petroleum, utility and marine industries have recognized the increasing need for heat exchange equipment and G-R has met these needs with progressive designs and manufacturing facilities. The requirements for increasingly higher temperatures and pressures have been met by G-R's 200 engineers, designers, draftsmen and by a well qualified manufacturing personnel. Today we serve a long line of established customers in all major industries.

Looking Forward

We are now on the threshold of the atomic age, a challenge to the engineering, designing and manufacturing ingenuity of our people. Nuclear power will necessarily supplant present day power supply systems as our resources of oil and coal are depleted. G-R has been engaged in research resulting in the production of heat transfer equipment for this field. Such equipment must operate under service conditions involving fluids at temperatures and pressures in the high ranges. Severe service conditions are also met with in the petro-chemical field, an industry which is still in its infancy. In the manufacture of heat transfer equipment of this kind the most exacting manufacturing techniques must be employed. G-R has the necessary facilities including X-ray and stress relieving, ultrasonic and dye penetrant testing, welding equipment and techniques requiring specially qualified and registered operators. The indications are that the heat transfer equipment of the future will demand that these manufacturing practices become routine procedures. As in the past, G-R is prepared. To those who have new problems involving heat transfer between any fluid mediums including liquid metals, G-R engineers are able to advise. It is probable that they have already met similar situations.

THE GRISCOM-RUSSELL CO.

MASSILLON, OHIO

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

GR366

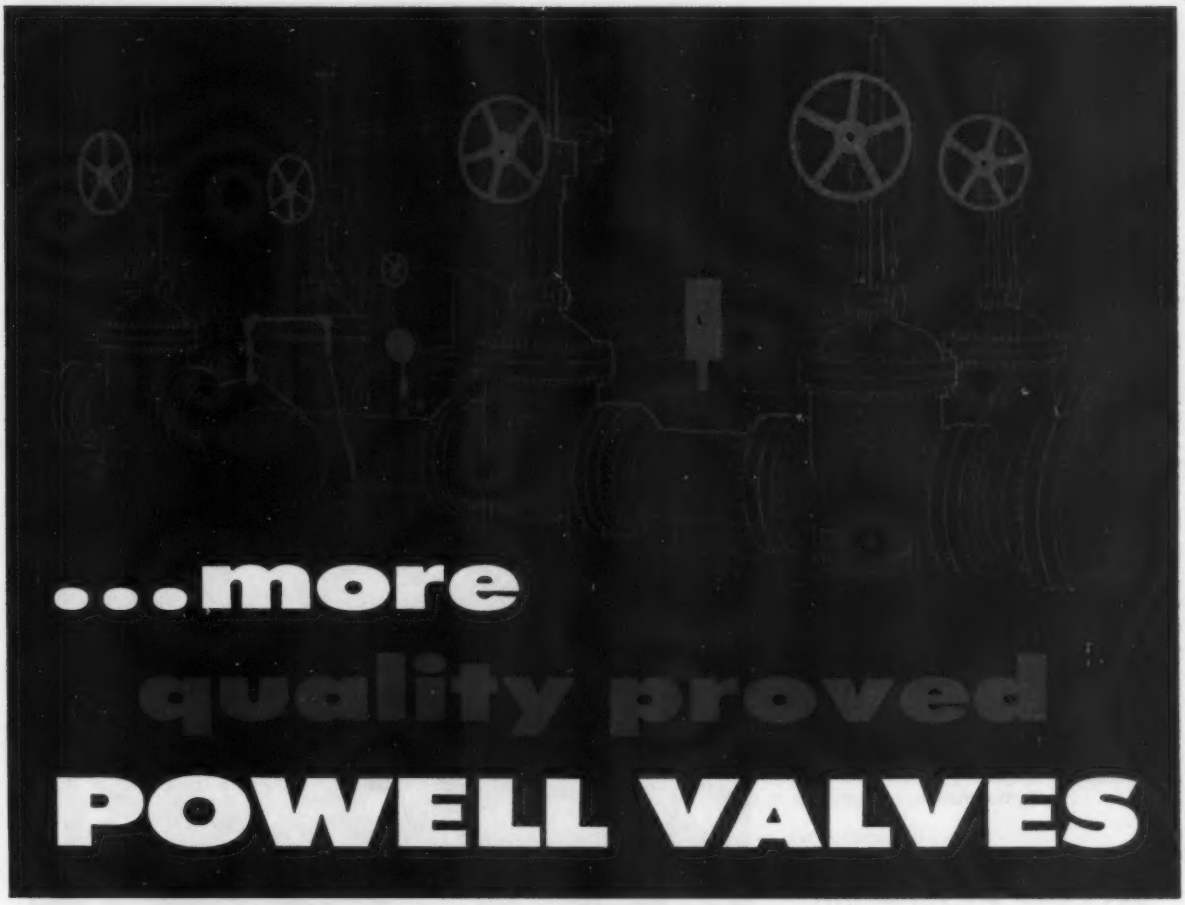


Fig. 3059G—300-Pound Steel Lubricated Plug Valve. Bolted Gland type. Gear Operated. Sizes 6" to 12".

Fig. 2467—Small Stainless Steel Gate Valve for 300 Pounds W.P. Outside screw stem and bolted yoke.

Fig. 86190—Steel "LPG" Globe Valve for 400 W.O.G. For services that demand the use of Steel Valves.

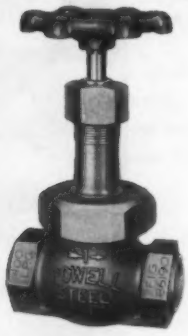
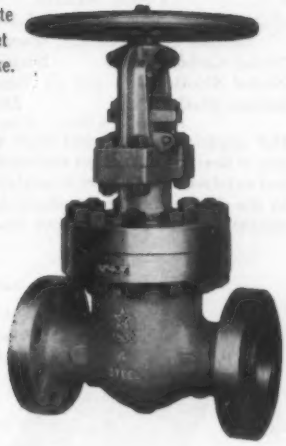


Fig. 1303—1500-Pound Steel Gate Valve with bolted flanged bonnet and outside screw stem and yoke.



made with quality proved materials

Consult your Powell Valve Distributor for full facts about quality proved bronze, iron, steel, and corrosion-resistant valves. For every flow control problem—there is a Powell Valve to solve it . . . *better.*

THE WM. POWELL COMPANY, CINCINNATI 22, OHIO . . . 111th YEAR

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Put HARSHAW CATALYSTS to work for you

Harshaw Catalysts do a giant's work and Harshaw produces catalysts in giant quantities—carloads every week. A letter or phone call will put our 20 years' experience and acres of production and research facilities to work for you.

PREFORMED CATALYSTS

to fit special process requirements

Hydroforming • Cyclization • Oxidation • Dehydrogenation • Dehydration • Desulphurization • Alkylation • Isomerization • Hydrogenation

CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

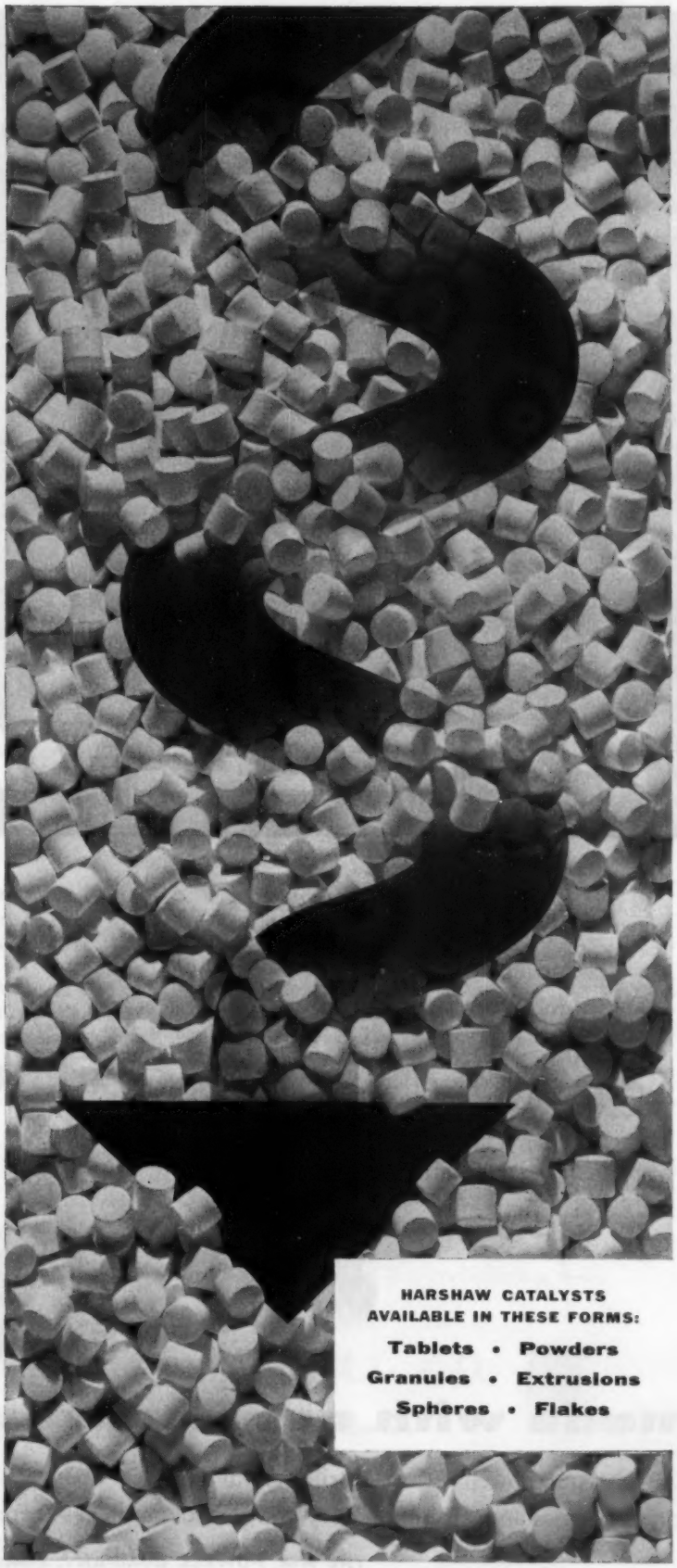
Aluminum Nitrate — Cobalt Nitrate
Copper Nitrate
Manganese Nitrate Solution
Metallic Soaps (Cobalt, Manganese)
Nickel Carbonate — Nickel Formate
Nickel Nitrate — Nickel Sulfate
Sodium Methoxide — Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

Write for Free Book

THE
HARSHAW CHEMICAL
COMPANY

Chicago • Cincinnati • Cleveland • Detroit
Hastings-On-Hudson, N. Y. • Houston • Los Angeles
Philadelphia • Pittsburgh



HARSHAW CATALYSTS AVAILABLE IN THESE FORMS:

Tablets • Powders
Granules • Extrusions
Spheres • Flakes

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FLUID CONTINUUM
a study in stainless steel by Robert Engman—Yale University for Fluid Systems, Incorporated

"PAMPERING WAX IS OUR BUSINESS"

Liquid wax is high on the list of delicate, temperature-sensitive products. In storage and in wax pipeline systems, heat density and temperature must be controlled exactly to eliminate costly spoilage.

A maintenance-free Thermal Electric® System automatically provides constant, even temperature throughout the entire wax handling system. Carefully controlled increments of low voltage, 60 cycle alternating current are applied to the same pipe in which the wax is contained. For heated storage, the same principle is utilized to warm pipe coils in the tanks.

The result is a pampered wax that is constantly surrounded by the gentle, even warmth that is your assurance of a quality product.

Thermal Electric Systems have been designed for:

American Can Co. . . . Continental Can Co., Inc. . . . Dixie Cup Co. . . . Columbia Ribbon & Carbon Mfg. Co., Inc. . . . Acee Pure Milk Co. . . . Waxide Paper Co. . . . Universal Machine Co., Inc. . . . Central Waxed Paper Co. . . . Riegel Paper Corp. . . . General Waxed Papers Corp. . . . Reynolds Metals Co.

Thermal Electric . . . the dependable, low-cost solution to off-site wax handling.

Trademarks Reg. U.S. Pat. Off.

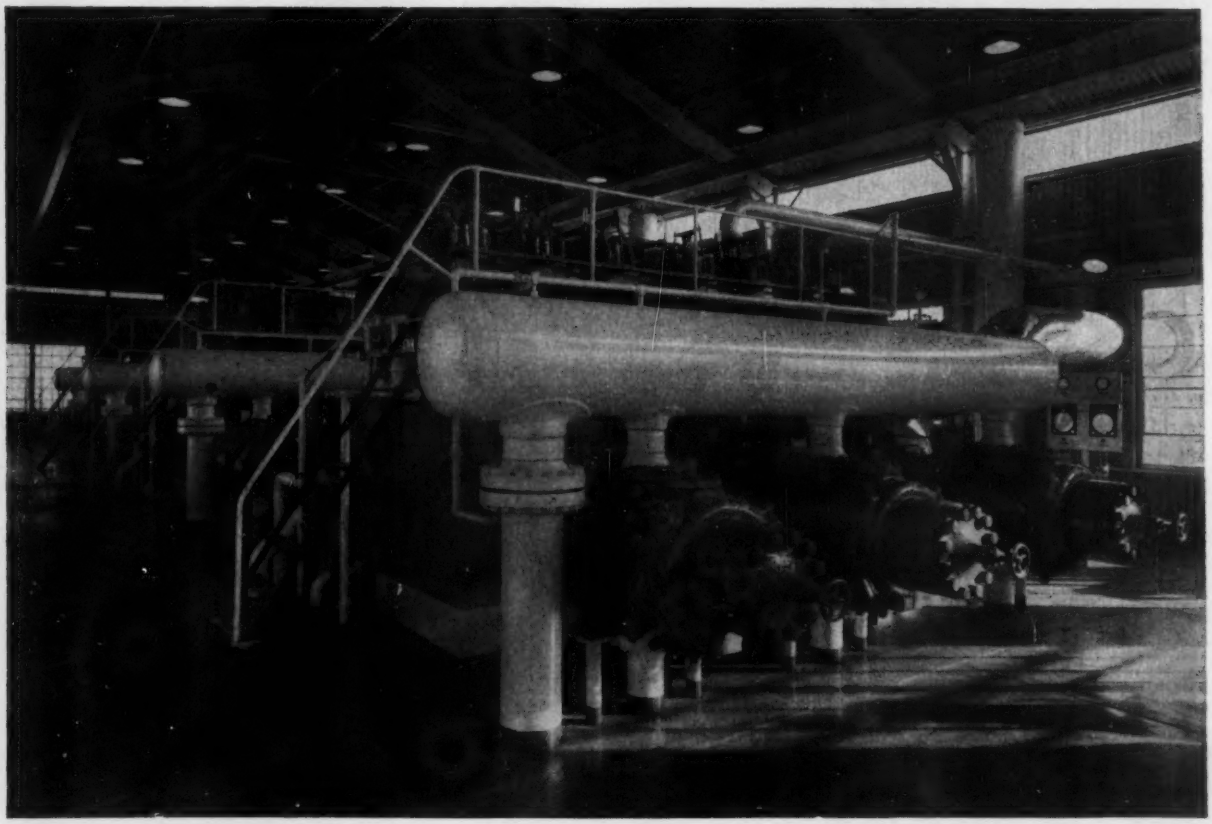
FLUID SYSTEMS INC.

1881 DIXWELL AVENUE • NEW HAVEN 14 • CONNECTICUT

NEW YORK • NEW HAVEN • CHICAGO

Fluid Systems INC.

HORSE



Since Clark introduced the world's first 2-cycle turbo-supercharged gas-engine-driven compressor in 1953, over 431,000 bhp. of these modern ultra-efficient units have been ordered by industry.

POWER

of Clark Turbo-supercharged Compressors now operating or on order

In the Clark tradition, these TLA and TRA units don't have to be babied or pampered when the going gets rough. Because they are specifically designed for turbo-supercharging rather than being beefed-up lightweights, they possess the stamina to back you up under the most difficult load conditions. Seven years of experimental and development work *prior* to their introduction make their outstanding performance possible.

The TLA-TRA have been field-proved by over 1,000,000 compressor hours on stream.

For modern, efficient, trouble-free compressor horsepower at its best, choose a Clark TLA-TRA. Seven models from 1100-3400 bhp.

CLARK BROS. CO., OLEAN, NEW YORK
One of the Dresser Industries
Offices in Principal Cities Throughout the World

CLARK DI

Turbo-Supercharged Compressors

For more data on advertised products, use Readers' Service Cards, last page.

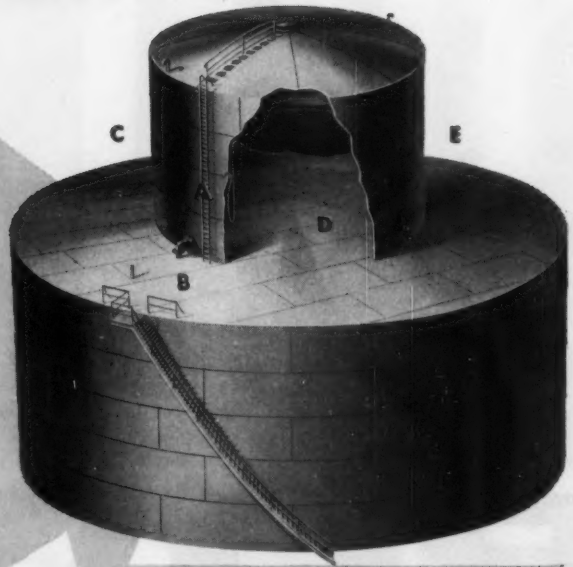
THE HAMMOND DIALIFT

the only membrane type conservation tank

... with full-rated vapor and product capacity at all times

... with a membrane that cannot come in contact with product

... with vapor space that can be isolated for inspection and maintenance without taking tank out of service.



Principle of the Hammond Dialift

A—DIALIFT DIAPHRAGM rises and falls to accommodate expanding and contracting vapor.

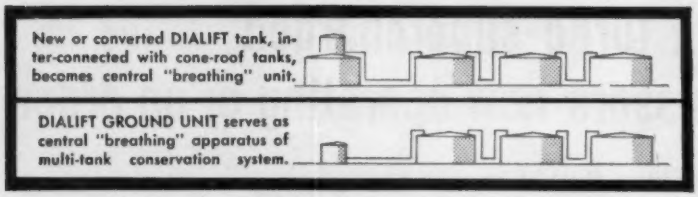
B—Vapor passes to and from tank and DIALIFT through simple elbow connection.

C—DIALIFT and tank have full-rated capacity.

D—Membrane can't come in contact with product.

E—DIALIFT can be isolated for maintenance and inspection, product tank stays in service.

The most efficient and economical vapor conservation system for new or old tanks.


New or converted DIALIFT tank, inter-connected with cone-roof tanks, becomes central "breathing" unit.
DIALIFT GROUND UNIT serves as central "breathing" apparatus of multi-tank conservation system.

THE HAMMOND DIALIFT consists of a gas-tight Vulcalock membrane attached to the inside periphery of a cylindrical metal housing to become a "breathing" apparatus to accommodate the expanding and contracting vapor as developed in product storage tanks. The DIALIFT can be used as a single conservation unit by being attached to the roof of a product storage tank or as a central "breathing" system by being manifolded to a number of product storage tanks. There are two forms of installation:—Ground type manifolded to a number of tanks to form a conservation system and integrated type whereby the DIALIFT is attached to the roof of a tank for vapor conservation for one or a number of tanks. The DIALIFT is completely isolated from the product storage tank. Vapor passes between the tank and DIALIFT through a vaporline connection. It is easy to convert old cone roof tanks to efficient vapor-saving DIALIFT installations by attaching a DIALIFT housing with membrane to the roof of the old tank and connecting the vaporline between the tank and DIALIFT.

THE HAMMOND DIALIFT ELIMINATES BREATHING LOSS AND REDUCES FILLING LOSS

Write for dialift catalog 55DL

HAMMOND IRON WORKS

HAMONDTANK

WARREN and BRISTOL, PA. • PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales Offices:

NEWARK 2, N. J. • BOSTON 10, MASS. • BRIDGEPORT, CONN. • CINCINNATI 2, OHIO • CHICAGO 3, ILL. ARLINGTON, VA. • GREENVILLE, S. C. • LOS ANGELES 57, CALIF. • MEXICO CITY • "IMPSA," BUENOS AIRES PORT-AU-PRINCE, HAITI • LIMA, PERU

Licensees: CALIFORNIA, CANADA, ENGLAND, BELGIUM, GERMANY, ITALY, FRANCE, AUSTRALIA, JAPAN, THE NETHERLANDS, COLOMBIA, BRAZIL

For more data on advertised products, use Readers' Service Cards, last page.

ROHM & HAAS, manufacturer of Plexiglas®, installs Dempster-Dumpster One-Man System to cut waste removal cost

BEFORE

"We no longer have to store waste materials in uncovered drums," says Mr. Roy Smelcher, Yard Superintendent of the Rohm & Haas Knoxville plant. "The Dempster-Dumpster System eliminates the rehandling and sweeping always necessary when using drums or barrels."

AFTER

Big 15-yard Dempster-Dumpster Containers like this one "make it possible for us to keep a cleaner, safer yard area at a much lower cost," reports Mr. Smelcher. This 15-yard Dempster-Dumpster is placed for convenient dock-loading.

Note how 15-yard Dempster-Dumpster Container is served by the truck-mounted Dempster-Dumpster.

Add ROHM & HAAS COMPANY to the thousands of users taking advantage of the economies provided by the DEMPSTER-DUMPSTER SYSTEM! Rohm & Haas officials at the Knoxville plant figure immediate man-hour reductions following their change-over to this one-man system will cut their waste materials collection and removal cost substantially. The fireproof DEMPSTER-DUMPSTER Containers also provide safe and temporary storage until rubbish is removed to the dump . . . eliminate rehandling of wastes . . . put a stop to insanitary accumulations of refuse and wastes. Write now for complete information. *Manufactured by Dempster Brothers, Inc.*

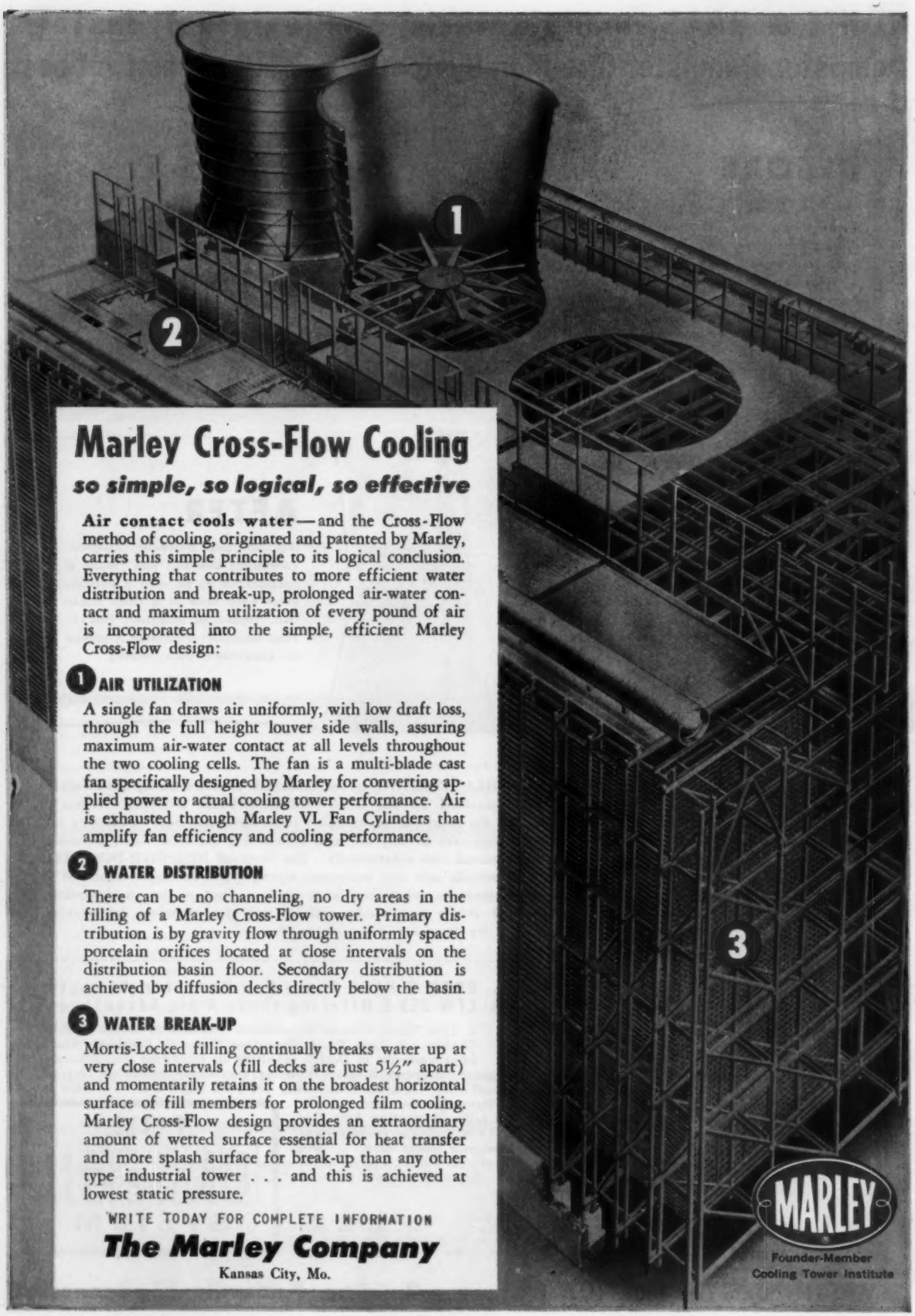
ROHM & HAAS Chose New Dempster-Dumpster LFW 253-C Offering these 4 Big Advantages:

1. Less Truck Chassis Investment. Mounts on 18,000# GVW Chassis. 2. Less Truck Operating Cost. 3. Combines Many Improvements in Design resulting in minimum maintenance. 4. Services All Dempster-Dumpster Bottom Dumping Containers including 15-yard capacities and Tilt and Skip Containers including 7½-yard capacities . . . Here is the ideal Dempster-Dumpster for many plants. Write for literature fully illustrating how this Dempster-Dumpster LFW 253-C serves any number of Dempster-Dumpster Containers . . . Detachable Containers of every design and size to meet each of your waste collection and removal requirements.

New Dempster-Dumpster Bottom Dumping Containers with SUMP BOTTOM eliminate dripping. Insist upon the Sump Bottom, which gives you an ALL-PURPOSE CONTAINER for moist, wet refuse as well as dry wastes!

THE DEMPSTER DUMPSTER® SYSTEM

DEMPSTER BROTHERS, 5107 Dempster Building, Knoxville 17, Tennessee



Marley Cross-Flow Cooling

so simple, so logical, so effective

Air contact cools water—and the Cross-Flow method of cooling, originated and patented by Marley, carries this simple principle to its logical conclusion. Everything that contributes to more efficient water distribution and break-up, prolonged air-water contact and maximum utilization of every pound of air is incorporated into the simple, efficient Marley Cross-Flow design:

1 AIR UTILIZATION

A single fan draws air uniformly, with low draft loss, through the full height louver side walls, assuring maximum air-water contact at all levels throughout the two cooling cells. The fan is a multi-blade cast fan specifically designed by Marley for converting applied power to actual cooling tower performance. Air is exhausted through Marley VL Fan Cylinders that amplify fan efficiency and cooling performance.

2 WATER DISTRIBUTION

There can be no channeling, no dry areas in the filling of a Marley Cross-Flow tower. Primary distribution is by gravity flow through uniformly spaced porcelain orifices located at close intervals on the distribution basin floor. Secondary distribution is achieved by diffusion decks directly below the basin.

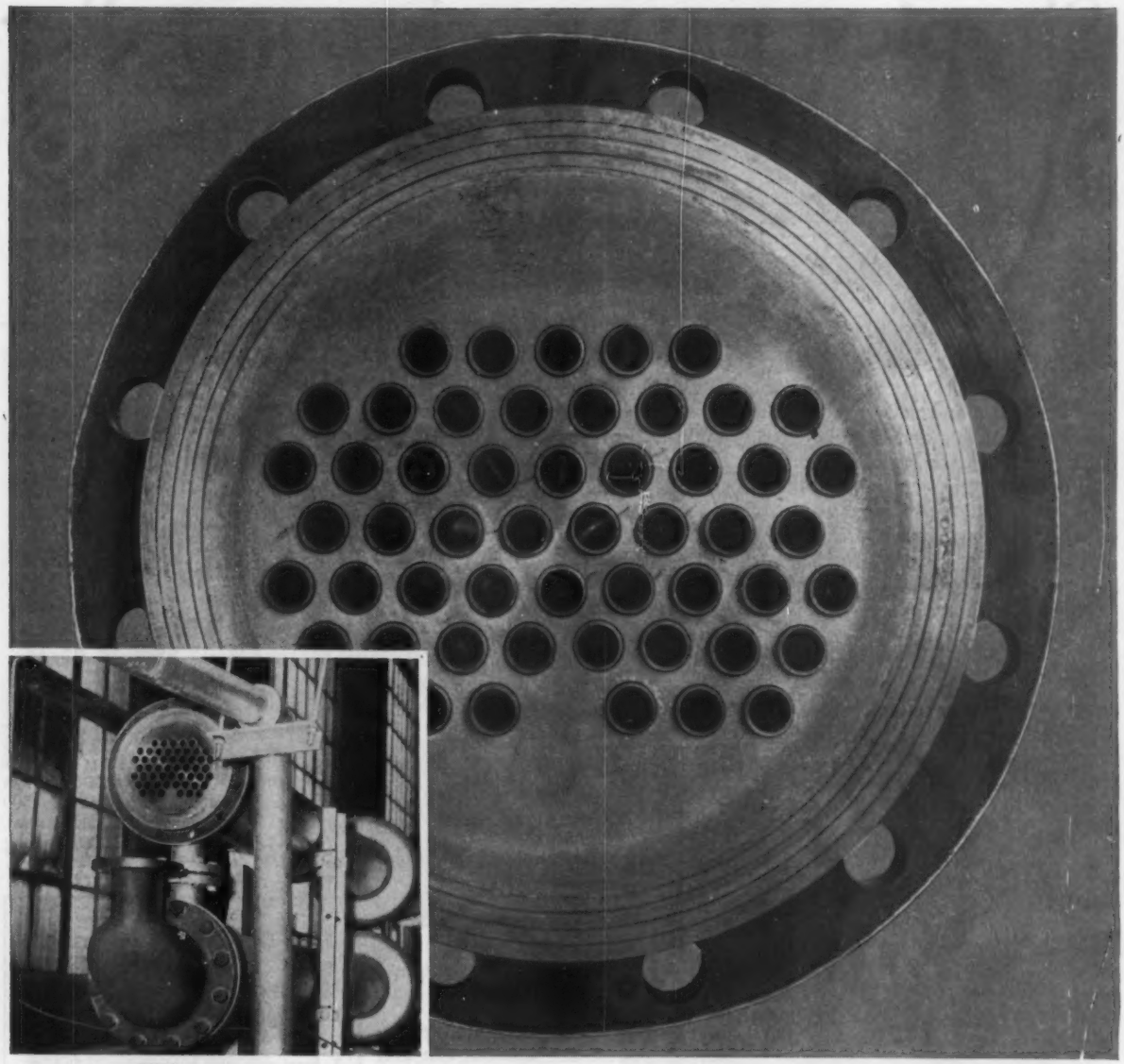
3 WATER BREAK-UP

Mortis-Locked filling continually breaks water up at very close intervals (fill decks are just 5½" apart) and momentarily retains it on the broadest horizontal surface of fill members for prolonged film cooling. Marley Cross-Flow design provides an extraordinary amount of wetted surface essential for heat transfer and more splash surface for break-up than any other type industrial tower . . . and this is achieved at lowest static pressure.

WRITE TODAY FOR COMPLETE INFORMATION

The Marley Company

Kansas City, Mo.



Carpenter 7Mo Stainless Tubing

No corrosion . . . no pitting after 4 years of handling hot SO_2 gases and vapors

• The smooth, clean surfaces of the Carpenter 7Mo Stainless tubing in this 3-pass Relief Gas Cooler tell the whole story. Still like new after 4 years of carrying 8% SO_2 gases and vapors from the top of a sulphite digester at temperatures in excess of 200°F. No maintenance. No replacement worries. No costly downtime.

If you have a tough corrosion problem involving stress corrosion cracking and pitting, see what Carpenter 7Mo Stainless Tubing and Pipe can do to solve it for good. Call your Carpenter Distributor for service that satisfies.

MEMBER

The Carpenter Steel Company
Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

Stainless Tubing & Pipe

For more data on advertised products, use Readers' Service Cards, last page.

Simplest pneumatic controller to use and maintain

Bristol gives you improved stability of control action —but keeps basic simplicity of Series 500 Controllers

Bristol Series 500 Pneumatic Controllers are the easiest controllers on the market to use and maintain—still the most dependable and trouble-free.

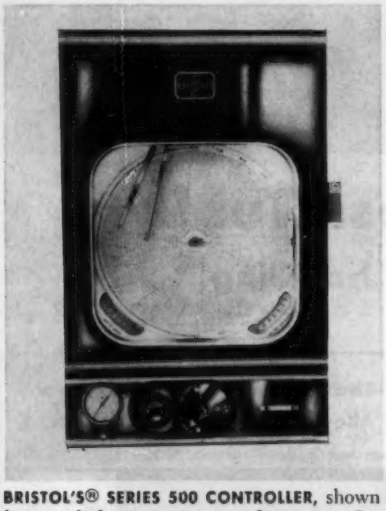
The reason? The basic simplicity of the operating mechanism. *That* hasn't changed in the years since we introduced this long-time favorite among instrument men. Reason No. 2: they are equipped with famous Bristol measuring elements.

Easy calibration

It's this foolproof simplicity of the control system that makes calibration so easy on Series 500 controllers. *Only one* service adjustment is required and provided to exactly calibrate the control system. The control system can be completely disassembled and after reassembly (even with replacement of parts) can be restored to precise calibration with this *one* adjustment.

No special tools are required. A ¼-inch wrench is all that's needed.

The 500's completely interchangeable parts, accurately designed and manufactured to extremely close tolerances, make possible this built-in calibration.



BRISTOL'S® SERIES 500 CONTROLLER, shown here with four-position transfer station. Internal station also available.

And check these features:

Improved control stability—advanced automatic control techniques have been applied by Bristol engineers to improve stability of control action in the new Series 500W Controllers.

Wide-band models offer choice of ½ to 400% proportional band with simple band shift.

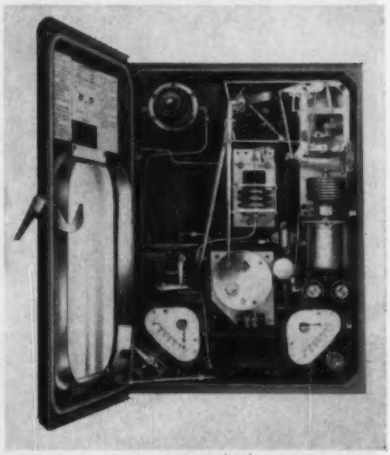
True zero derivative setting—exclusive with Bristol.

Reset action stops in reset models—again a Bristol exclusive—prevent loss of control due to prolonged deviation from set point.

Four-position internal transfer station with automatic, manual, test, and service positions, plus pressure-matching button and manual pressure regulator, for maximum convenience in process control.

Complete data available

Write today for engineering data on Bristol's Series 500 controllers for your critical control problems. They're available for *automatic control of temperature, pressure, vacuum, draft, absolute pressure, liquid level, humidity, pH value, electrical measurements, and mechanical motion.* The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.



FOUR-POSITION INTERNAL TRANSFER STATION shown here in interior view of Series 500 Controller. Permits remote manual control, testing and servicing without disconnecting instrument.

YOU CAN GET THESE CONTROL MODES:

1. **Fixed narrow band** (on-off)
2. **Proportional band**—½ to 100% and ½ to 30%.
3. **Reset with wide band**—rates 0.1 to 10 or 1 to 300 repeats per minute. Proportional band ½ to 400%.
4. **Derivative (rate)**—½ to 100% proportional band. Derivative time 0.2 to 20 min., plus zero derivative setting.
5. **Reset plus derivative**—proportional band and reset rate as in "reset" above. Derivative time as in "derivative" above.

YOU CAN HANDLE THESE CONTROL PROBLEMS:

1. Cascaded control 2. Selective control 3. Ratio control 4. Time-program control 5. Pneumatic transmission.

6.55

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Expert Fabrication of

PROCESS EQUIPMENT

IN ALL METALS

Struthers Wells is one of the nation's most widely known fabricators and welders of Code pressure vessels and other processing equipment in all metals. One of the first to adopt welding and eliminate riveted construction, Struthers Wells has taken distinct leadership in the welding of stainless steel, nickel, Hastelloy, Monel, Everdur, Titanium and other metals used by the processing industry. For the best in process equipment, look to Struthers Wells.

Super-safety, quick operating (45 seconds) pressure vessel doors are another SW specialty.

Quick Opening
DOORS
FOR PRESSURE VESSELS

STRUTHERS WELLS PRODUCTS

PROCESSING EQUIPMENT DIVISION
Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

BOILER DIVISION
BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

FORGE DIVISION
Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Back-up Rolls

MACHINERY DIVISION
MACHINERY for Sheet and Structural Metal Forming . . . Tangent Benders . . . Folding Machines . . . Roller Table and Tumble Die Bending Machines . . . Press Brakes . . . Punching and Notching Machines . . . Forming Dies

STRUTHERS WELLS *Corporation*

TITUSVILLE, PA.

Struthers Wells

Plants at Titusville, Pa. and Warren, Pa.

Offices in Principal Cities

For more data on advertised products, use Readers' Service Cards, last page.

In Iron Body Wedge Gate Valves,
Outside Screw and Yoke Design,

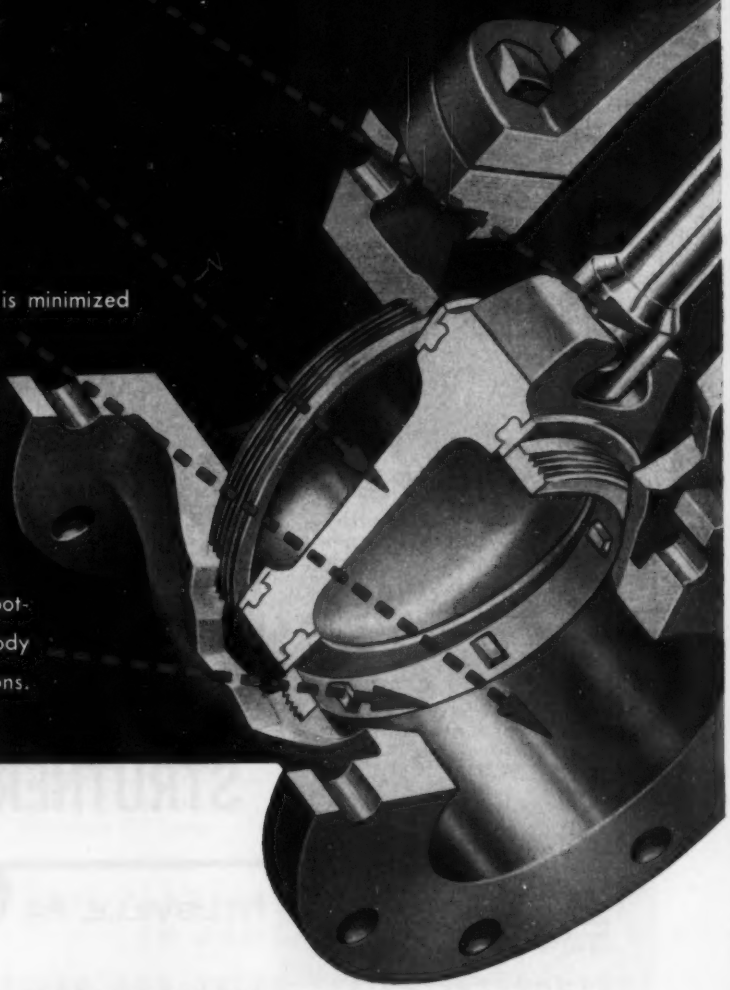
Walworth offers you these 8 outstanding advantages!

STRONGER CONNECTIONS. T-head disc-to-stem connection on OS&Y types permits wedge to properly seat itself.

TIGHTER SEAL. Solid web type disc on OS&Y valves provides tight closure, greater strength and longer service.

REDUCED TURBULENCE. Fluid action is minimized due to this straight-flow port design.

FEWER OBSTRUCTIONS. Seat rings of bottom-seated types are screwed into body to prevent gum and grit accumulations.



*WALWORTH is a registered trademark of WALWORTH COMPANY

Walworth Subsidiaries: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO.

SURE-GRIP HANDWHEEL. Fluted design assures a sure grip, even with greasy gloves.

HIGH CORROSION RESISTANCE. Brass liner protects glands from deterioration and scoring.

EASIER REPACKING. Hinged gland eye-bolts on OS&Y valves permit fast maintenance under full pressure.

LESS DAMAGE. Bronze back-seat bushing in bonnet of OS&Y valves prevents scoring, guides stem accurately.

Walworth Iron Body Gate Valves are available with screwed or flanged ends, in sizes and types for every purpose. For full information see your Walworth Distributor or write: *Walworth Company, 60 East 42nd Street, New York 17, N. Y.*

WALWORTH*

DISTRIBUTORS IN PRINCIPAL CITIES THROUGHOUT THE WORLD

M & H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING AND WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.

For more data on advertised products, use Readers' Service Cards, last page.

Stainless steel lining extends life of catalytic polymerization tower

Two months after going on stream, this catalytic polymerization tower shut down. Its carbon steel plates had corroded halfway through.

Phosphoric acid catalyst, temperatures up to 375°F, and pressures up to 500 pounds per square inch did the damage.

Refinery engineers then had a fabricator line the tower with Type 316 chromium-nickel stainless steel . . . and put in stainless caps and trays.

After 21 months of service, inspection showed the stainless lining still in excellent condition, with many more months of service yet to come.

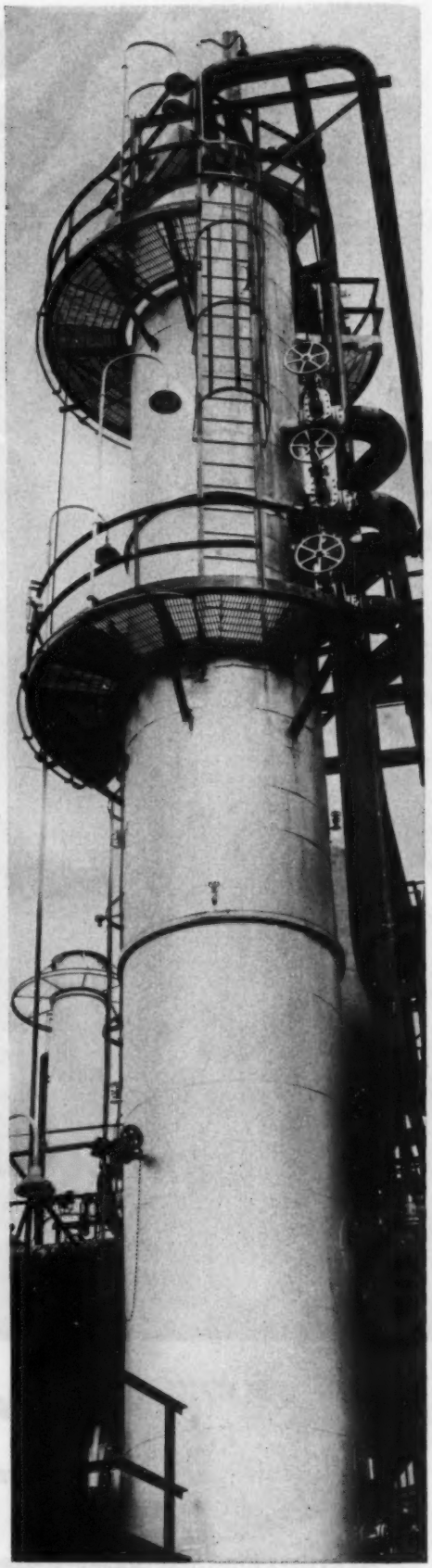
For your corrosion problem . . . it may pay you to consider the properties of chromium-nickel stainless steel. It provides not only outstanding corrosion resistance, but also high strength, fabricability and ease of cleaning. Inco's Corrosion Engineering Section has a large amount of information on stainless steels . . . and many other alloys used in the petroleum industry. We'd be glad to share this data with you.

For immediate reference . . . the 34-page booklet, Corrosion Resisting Properties of the Austenitic Stainless Steels, discusses mechanism and factors of corrosion in various atmospheres. If you'd like to have a copy of this informative, useful handbook, just send a postcard to Inco.

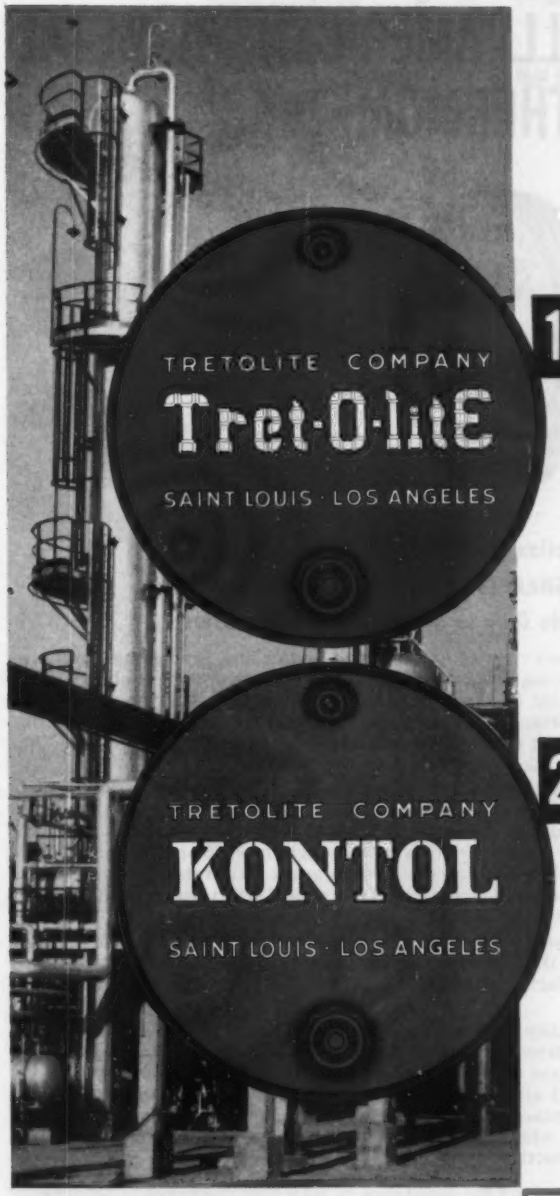
The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK

INCO NICKEL



the most ECONOMICAL maintenance is PREVENTIVE maintenance



TWO OF THE MOST EFFECTIVE PREVENTIVE MAINTENANCE MEASURES ARE:

1 *98% to 100% SALT REMOVAL with Tretolite Chemical Desalting*

Tretolite Desalting prevents salts, solids, trace metals and other impurities from entering the refinery stream. It prevents salt plugging and fouling in condensers, exchangers and towers, reducing clean-outs and tube rattling to minimum. Tretolite Desalting is an automatic, all-chemical process that consistently delivers salt removals in the 98% to 100% range.

2 *EFFICIENT CORROSION PREVENTION with Kontol Corrosion Inhibitors*

Kontol Corrosion Inhibitors prevent internal corrosion and hydrogen blistering and help to eliminate scale and fouling difficulties. Kontols are readily adsorbed from hydrocarbon solutions at metal surfaces to form a tough impervious film. In addition to their inhibiting properties, the Kontols are powerful detergents which clean and de-foul refinery equipment.

Ask the man in the red car

The Tretolite Service Engineer is always on call to assist you in your maintenance and processing problems.

AR-57-1

TRETOLITE COMPANY

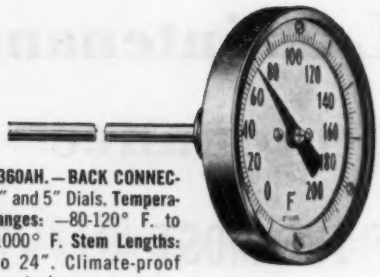
A Division of Petrolite Corporation

369 MARSHALL AVENUE, ST. LOUIS 19, MISSOURI
5515 TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA

Chemicals and Services for the Petroleum Industry

DESALTING • DEMULSIFYING • CORROSION INHIBITING • SCALE PREVENTING
FUEL OIL ADDITIVES • WATER DE-OILING • METAL DEACTIVATORS

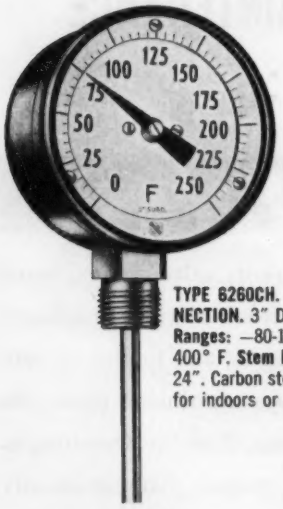
For more data on advertised products, use Readers' Service Cards, last page.



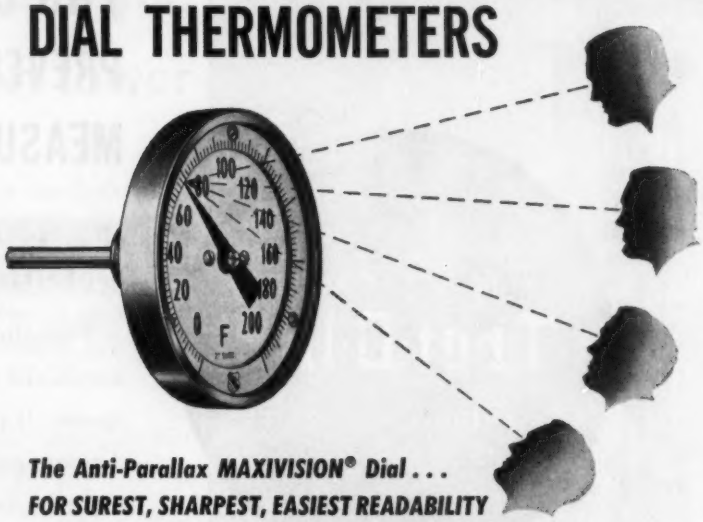
TYPE 6360AH.—BACK CONNECTION. 3" and 5" Dials. **Temperature Ranges:** —80-120° F. to +200-1000° F. **Stem Lengths:** 2½" to 24". Climate-proof stainless steel case.

GET ACCURATE "ON-THE-SPOT" TEMPERATURE READINGS...

INSTALL 'AMERICAN' BI-METAL DIAL THERMOMETERS



TYPE 6260CH.—BOTTOM CONNECTION. 3" Dial. **Temperature Ranges:** —80-120° F. to +50-400° F. **Stem Lengths:** 2½" to 24". Carbon steel case suitable for indoors or outdoors.



The Anti-Parallax MAXIVISION® Dial... FOR SUREST, SHARPEST, EASIEST READABILITY ...Is Available Only In 'American' Thermometers

TYPE 6060AH. — "EVERY ANGLE" CONNECTION. 5" Dial. **Temperature Ranges:** —80-120° F. to +200-1000° F. **Stem Lengths:** 4" to 24". Climate-proof stainless steel case.

Nowadays fewer men are required in power and processing plants to inspect operations, so it is more important than ever to have observation points handy for them. 'American' Bi-Metal Dial Thermometers, installed at important check points, eliminate frequent trips to the control house. Inspectors can observe variations in process temperatures "on the spot" and take steps to effect corrections.

The economy of these thermometers goes far beyond the time-saving convenience of local indoor and outdoor readings. Their accuracy and utility contribute to lower costs. They provide the greatest sensitivity in bi-metal actuation. The low-mass single helix bi-metal coil is precisely centered in the stem to assure quick, accurate response to all temperature changes — to prevent the retard effect the coil can cause if rubbed against the stem wall.

The Maxivision dial is a split-level dial with pointer set on the same plane as the outside raised ring that carries the graduations. No perspective effect, no parallax! Readings are sure, sharp and accurate at a glance!

The availability of 'American' Bi-Metal Dial Thermometers in types with back, bottom or "Every Angle" connection permits selection to fit the conditions of each location. For example, the "Every Angle" type can be set at any point within 180° on two axes. Thus it is particularly recommended for installation above or below eye level or in close quarters where the types with fixed back or bottom connection would be impractical.

PHONE YOUR INDUSTRIAL SUPPLY DISTRIBUTOR for assistance in selecting the types of 'American' Bi-Metal Dial Thermometer best suited to your needs. He can provide separable sockets in all materials and sizes normally required.

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*

AMERICAN INDUSTRIAL INSTRUMENTS

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONN.

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.* AIRCRAFT CONTROL PRODUCTS, *Danbury, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

pumps, pours, dissolves under any condition

UOP AW(50)*

COPPER DEACTIVATOR

Even in exposed, below-freezing locations, UOP AW(50) Copper Deactivator flows readily, doing away with low-temperature pumping problems common to ordinary deactivators. And, whether you use AW(50) in the five-gallon manual-application size, or 55-gallon drums for automatic injection, it will not freeze and can be easily pumped even when stored for long periods at temperatures as low as 0°F.

In addition to superior pouring properties under low-temperature conditions AW(50) gives maximum metal deactivating efficiency and economy. It is instantly soluble in hydrocarbons, and is light in color.

UOP AW(50) is a "must" for refiners stabilizing gasoline, jet fuel, domestic heater oil and diesel fuel in all northern latitudes where temperature drops are extreme.

*Trade Mark

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD
DES PLAINES, ILLINOIS, U.S.A.

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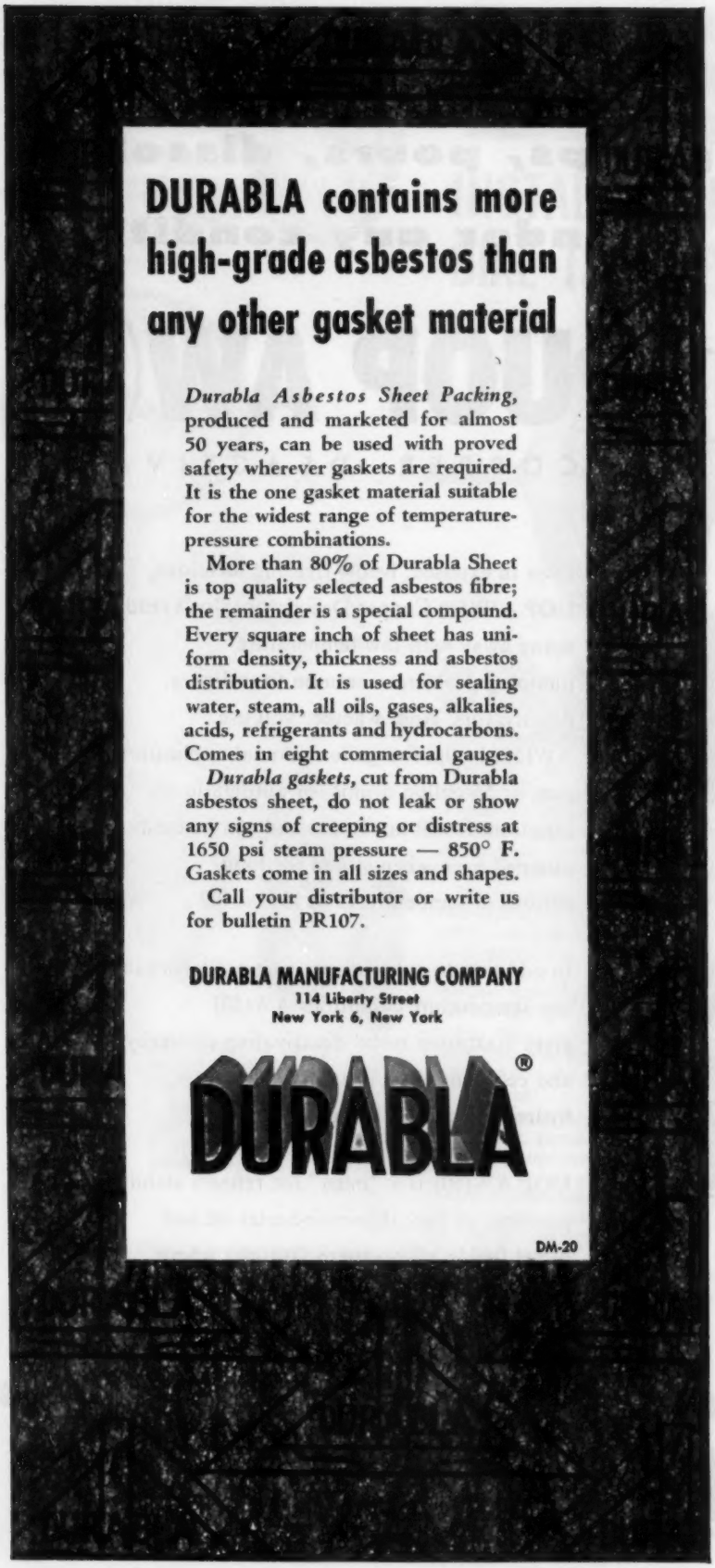

DURABLA contains more high-grade asbestos than any other gasket material
Durabla Asbestos Sheet Packing, produced and marketed for almost 50 years, can be used with proved safety wherever gaskets are required. It is the one gasket material suitable for the widest range of temperature-pressure combinations.
More than 80% of Durabla Sheet is top quality selected asbestos fibre; the remainder is a special compound. Every square inch of sheet has uniform density, thickness and asbestos distribution. It is used for sealing water, steam, all oils, gases, alkalies, acids, refrigerants and hydrocarbons. Comes in eight commercial gauges.
Durabla gaskets, cut from Durabla asbestos sheet, do not leak or show any signs of creeping or distress at 1650 psi steam pressure — 850° F. Gaskets come in all sizes and shapes.
Call your distributor or write us for bulletin PR107.
DURABLA MANUFACTURING COMPANY
114 Liberty Street
New York 6, New York
DURABLA®
DM-20

The Mail Box . . .

Something Missing

To the Editor:

I am in the process of reading the August issue of the PETROLEUM REFINER—Special Report on Turbine Drives. If you have a separate issue of these articles available, please send me a copy.

As in all special reports there is something that does not receive the acclaim it merits. In the chapter entitled, "How Turbines Can Work In Your Process," there should have been an inclusion of the expander-turbine that is not associated directly with an air combustion chamber as a source of force.

George L. O'Connor
Stratos Division-Fairchild
Houston

To The Editor:

The digest which you prepared (of "Consider the Economics of Scale-Up," page 268, September, 1957 issue of PETROLEUM REFINER), I think, would have been improved by being more complete. I presume that space did not permit the inclusion of a few more points such as that which I raised in the penultimate paragraph of the paper suggesting the breakdown of costs into groups and scaling up these figures by applicable exponents between 1.0 and 0.6.

F. G. Dickerson
Engineering Division,
The Distillers Company, Ltd.
London

Be Sure To Check This Month's Classified Section in REFINER

Need Engineers - Technical Personnel? Try a Classified Ad in Petroleum REFINER.

QUICK! ECONOMICAL! RESULTFUL!

Help Wanted! Classified Ads in Petroleum REFINER get the job done.

For more data on advertised products, use Readers' Service Cards, last page.

the Switch is to PYLE-NATIONAL

industrial lighting fixtures

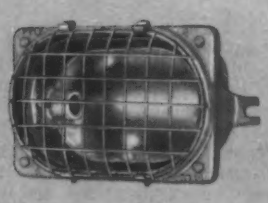
EXPLOSION-PROOF
LE Series (Class I, Groups C and D)
60 to 500 Watts
Choice of body and reflector styles

EXPLOSION-PROOF Floodlights
FEA Series 150 to 300 Watts

DUST-TIGHT
DE Series (Class II, Groups E, F and G and Class III)
60 to 200 Watts
Choice of body and reflector styles

VAPOR-TIGHT
DO Series 10 watt signal or pilot lights
BO Series 50 to 500 watts
Choice of body and reflector styles

FLUSH VAPOR-TIGHT
Type 1570 Pit and subway lights
100 and 200 watts



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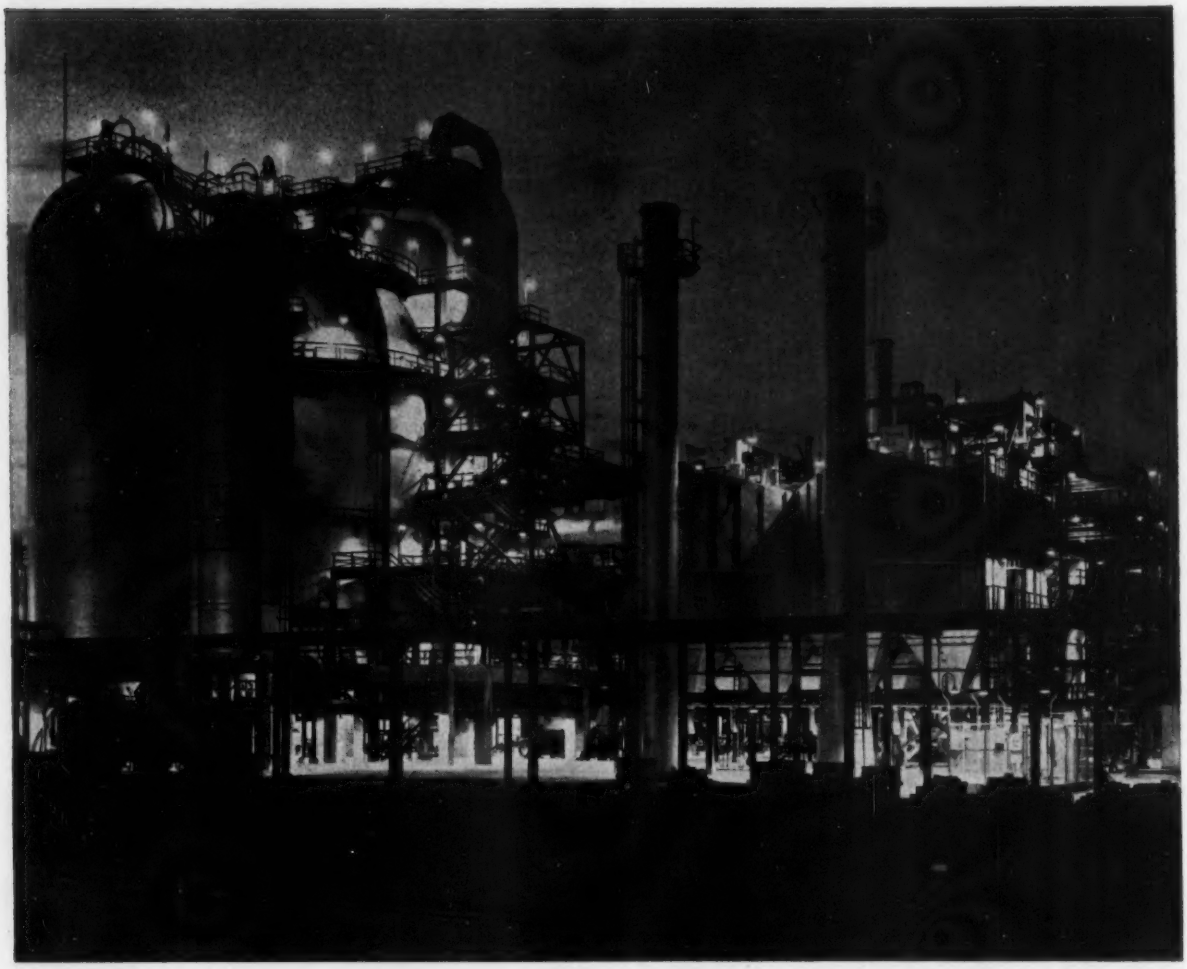

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A Quick Look at the Industry THIS MONTH

Refining Outlook: ???? . . . During last quarter of '57, refiners will have one wary eye on uncertain supply-demand picture, other on government actions concerning imports, small business investigations and defense oil purchases.

Inventories Still Shaky. Chase Manhattan says stocks appeared to be excessive by about 75 million barrels at the end of August. Inventories rose 17 million barrels during the month to reach new high of 840 million barrels, including 20 million barrel addition to refined product stocks.

Result: Oversupply, plus inadequate corrective efforts, has pushed price of several refined products to lower levels. However, due to improved inventory position, gasoline prices, for the most part, have been excluded from downward trend. This exclusion could be short-lived if refinery runs continue at excessive rate.

Demand Revised Downward. BuMines has changed its forecast for '57 domestic petroleum demand. At beginning of year, '57 prediction called for 5.2 percent increase over '56. New forecast predicts boost of less than than 2 percent in demand rate. Gasoline demand will average 3.97 million bpd, up 3.1 percent over '56.

Ethyl Corp. foresees automotive gasoline demand increasing at average annual rate of 3.7 percent during next four years, averaging more than 4 million bpd in '61.

Big Test for Voluntary Imports . . . Predictions are that importers, particularly the seven companies requesting higher allocations, likely will not comply with government's voluntary program. To meet objectives, imports would have to be reduced to about 653,000 bpd by next June (vs. 850,000 bpd average in last half of '57.)

Meanwhile, independent refiners and others are questioning military's purchase of Caribbean jet fuel. Argument: If military purchases jet fuel outside of U. S. for price reasons alone, then refiners should have equal right to import greater quantities of low cost crude.

New Look at Defense Purchases . . . Top Pentagon officials are re-appraising defense oil procurement situation. Two-month study (to end in Nov.) covers military product imports, ways to reduce commitments under Pentagon's cutback order, and small business set aside.

Independent refiners fared well at latest awarding of jet fuel contracts. Small business set aside totaled 4.6 million barrels, .64 million barrels more than had previously been reserved for Oct.-Mar. period.

Test for Vapor Lock . . . General Motors has found new way to measure gasoline vapor pressure. Now used throughout the corporation, test is claimed to give a better idea of vapor locking tendencies in auto fuels—much better than present Reid vapor pressure apparatus. Basically, though, it's a variation of the Reid test.

New Engine Developments . . . Though talk about gas turbines for passenger cars has cooled down, they are considered both practical and feasible for heavy duty and military vehicles. No engineering breakthroughs are required to put heavy turbine vehicles on the road. Needed: Additional work in development and manufacturing areas.

Free piston developments are not so mature. Recently, Ford designed a free piston engine for farm tractors. However, greatest advantage may not be realized if it is used only as a substitute for gasoline or diesel engines.

Diesel engine still looks like best bet in the future as power plant for heavy duty commercial vehicles. It's undergoing development, too. Turbocharging appears to be next step.

A Quick Look at the Industry (continued)

More Products from Canada . . . Watch for sharp upturn in construction outlays in new natural gasoline and petrochemical plants in Western Canada within next two or three years. Reasons: Natural gas, long held back due to lack of adequate markets, will start moving in large volumes through Westcoast Transmission line to Pacific Northwest by end of this year, and within another year or so, Trans Canada's big line will be moving gas to eastern markets.

Natural Gas Vs. Fuel Oil . . . Natural gas is being substituted for fuel oil by Los Angeles industries to reduce air pollution on days of heavy smog. Upon a signal from the Air Pollution Air Control District that alert conditions are forecast, industrial users will switch to natural gas, thus reducing by about 500 tons total pollution being emitted daily.

New Way to Check Combustion Heat of Avgas . . . Combustion heats of aviation gasolines can be estimated conveniently and reliably with new method developed by National Bureau of Standards. It does not require elaborate calculations nor extensive analytical work, but is based on an empirical equation relating heat of combustion to proportions of various hydrocarbon types present. Adaptable for use by refineries, procedure is expected to prove useful in checking aviation gasolines for conformance to military specifications.

Plastics Boom in Japan . . . Look for Japan to assume leading role in plastics production. Now ranking fourth in world production, Japan is making 340,000 tons a year—may be ahead of Britain by '59, and only slightly behind West Germany.

Exports have doubled every year for the past five years, biggest increase being in polyvinyl chloride. Four new polyethylene plants are being built or designed under licenses from U.S. and Western Europe.

Refiners to Use More Boron? . . . Though still largely unexplored, recent research findings indicate that organo-borons have broad application potential as gasoline additives and plastics. (At least one refiner has been using boron additives for more than a year.) Many borate esters have been produced including methyl, isopropyl, butyl, tetradecyl and numerous others.

Due to increased use in high energy fuels, about 800,000 short tons of boron minerals and compounds are being produced in the U.S. annually—most of which are low-priced compounds. However, situation will change when this vast new field opens up.

Needed: More Economical Way to Convert Natural Gas . . . After demonstrating feasibility of hydrocarbon synthesis from natural gas, Amoco Chemicals was forced to shut down its Brownsville plant. Reason: Process could not compete economically with other methods. Plant is expected to remain down as long as economic relation of products and charge remains unchanged.

New Fields Show Promise . . . The nation's oil field list grew by 82 during August. Of the five best lookers, Texas furnished four and Wyoming one. Two of these were in West Texas, one drilled in Upton County by Pure and gaged at 645 barrels of 40-gravity crude a day, and the other was Atlantic's Winkler County strike flowing 145 barrels of 36-gravity daily. Great Expectations Oil and Amerada teamed to drill a discovery in Marion County, East Texas, good for 540 barrels of 41-gravity oil, and Mound Company's Austin County, Gulf Coast, find flowed 115 barrels of 41-gravity daily. Pan-American owns a new 535-barreler in Carbon County, Wyoming.

How to tame a dust collection problem

Look for the 'hidden' factors that deliver important *extra efficiency*, like the exclusive Shave-off in Buell Cyclones that harnesses the double-eddy currents to trap an extra percentage of dust. Side-entry of gases, Buell-designed manifolds, proper proportioning, extra-heavy-plate construction provide even more efficiency. Send for the ready reference booklet, "The Collection and Recovery of Industrial Dusts". Dept. 21-J, Buell Engineering Company, Inc., 70 Pine Street, New York 5, New York

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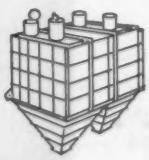

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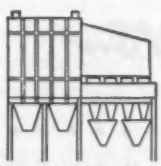

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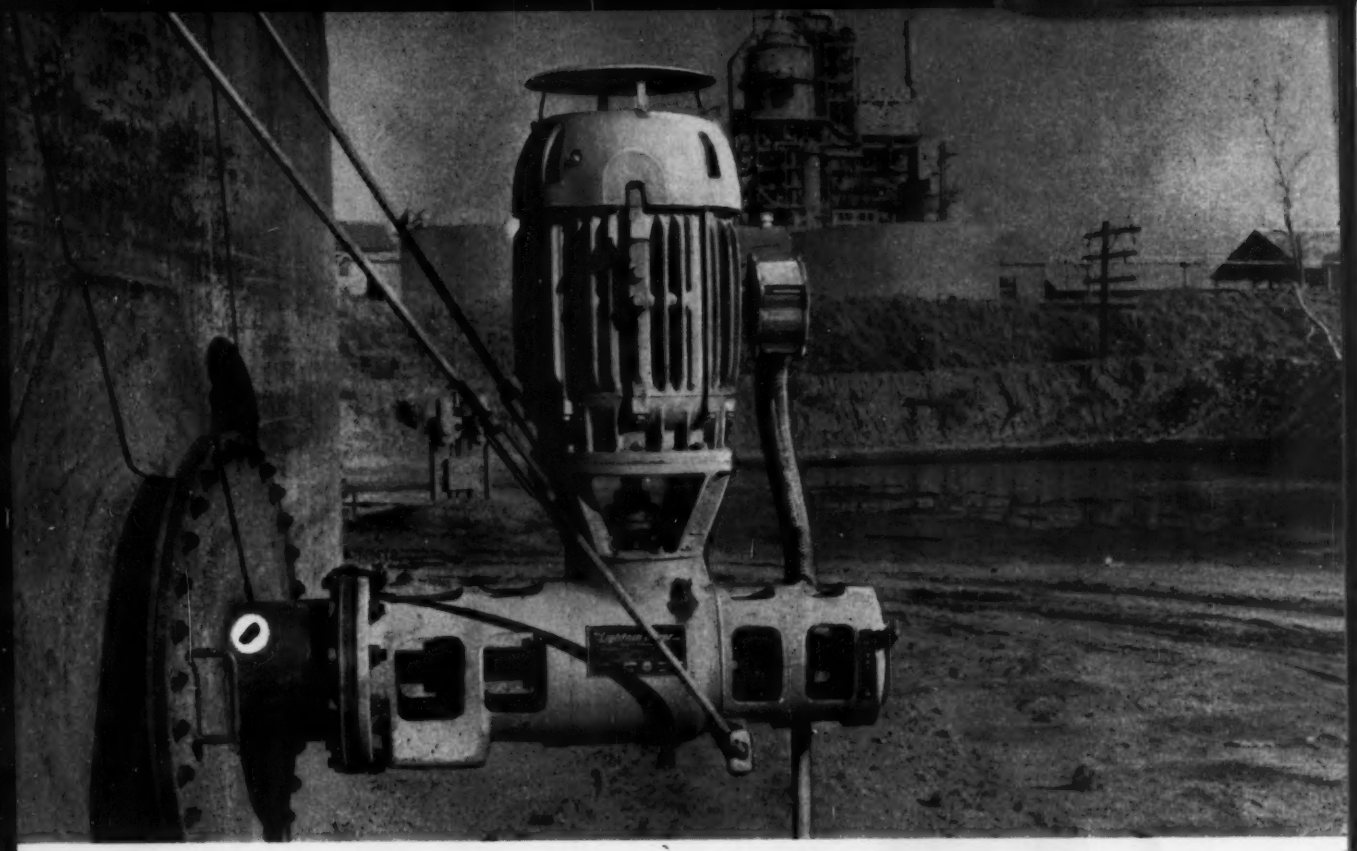

Why you **never** *have to repack this mixer*

This idea can save you, eventually, nearly every dollar you spend to service mixer stuffing boxes on your big tanks.

There's no stuffing box on this LIGHTNIN Mixer! Instead, a rotary mechanical seal stops leakage—and stops it for *years*—without need of adjustment.

Replace seal in minutes

Better yet, you can replace *this* seal in a hurry if you ever need to.

You don't have to dismantle the mixer to replace it.

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And you don't need a bevy of skilled specialists; it's a one-man, one-wrench job.

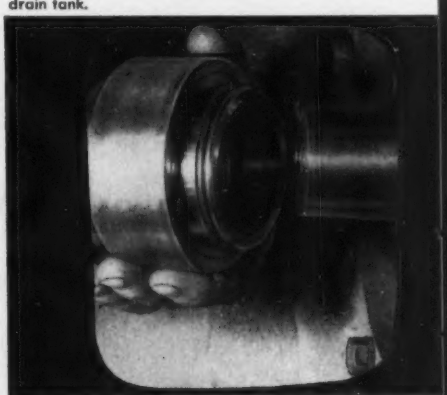
You slide the one-piece LIGHTNIN seal cartridge off the uncoupled mixer shaft. Slide a new cartridge in place, secure it, recouple the shaft—and you're back in business.

Only LIGHTNIN has it

You get the LIGHTNIN seal as optional equipment on any new LIGHTNIN Side Entering Mixer. You can get it to handle the toughest operating conditions —or the simplest.

It's saving refiners many thousands of dollars per year on mixer maintenance. How much can it save *you*? Call your LIGHTNIN Mixer representative (listed in Refinery Catalog) for the full story. Or get facts by mail: send us the coupon for 8-page fully illustrated bulletin.

1. IF YOU EVER NEED TO REPLACE a LIGHTNIN shaft seal, here's how fast you can do it. Close mixer shutoff to hold liquid in the tank. No need to drain tank.



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EVERY NOW AND THEN we like to remind our readers that PETROLEUM REFINER is one of 11 oil industry publications (there are about 30 in all) which are allowed to carry the symbol of the Audit Bureau of Circulations.

"What's so important about belonging to ABC?" you may ask. The answer lies in the a-b-c's of business publication philosophy:

A. To keep from charging you about $20 a year for one PETROLEUM REFINER subscription (compared with our present rate of $2 per year), we must have advertisers.

B. To have advertisers, we must attract enough of the right type of subscribers. The right type are those high enough in their company to influence the purchase of equipment and supplies.

C. And, to attract enough of the right type of subscribers, we must provide a high quality editorial service to our readers.

This is where the Audit Bureau of Circulations comes in. The Bureau sets standards for the definition and measurement of paid circulation, verifies adherence to those standards by its publisher members and disseminates circulation reports.

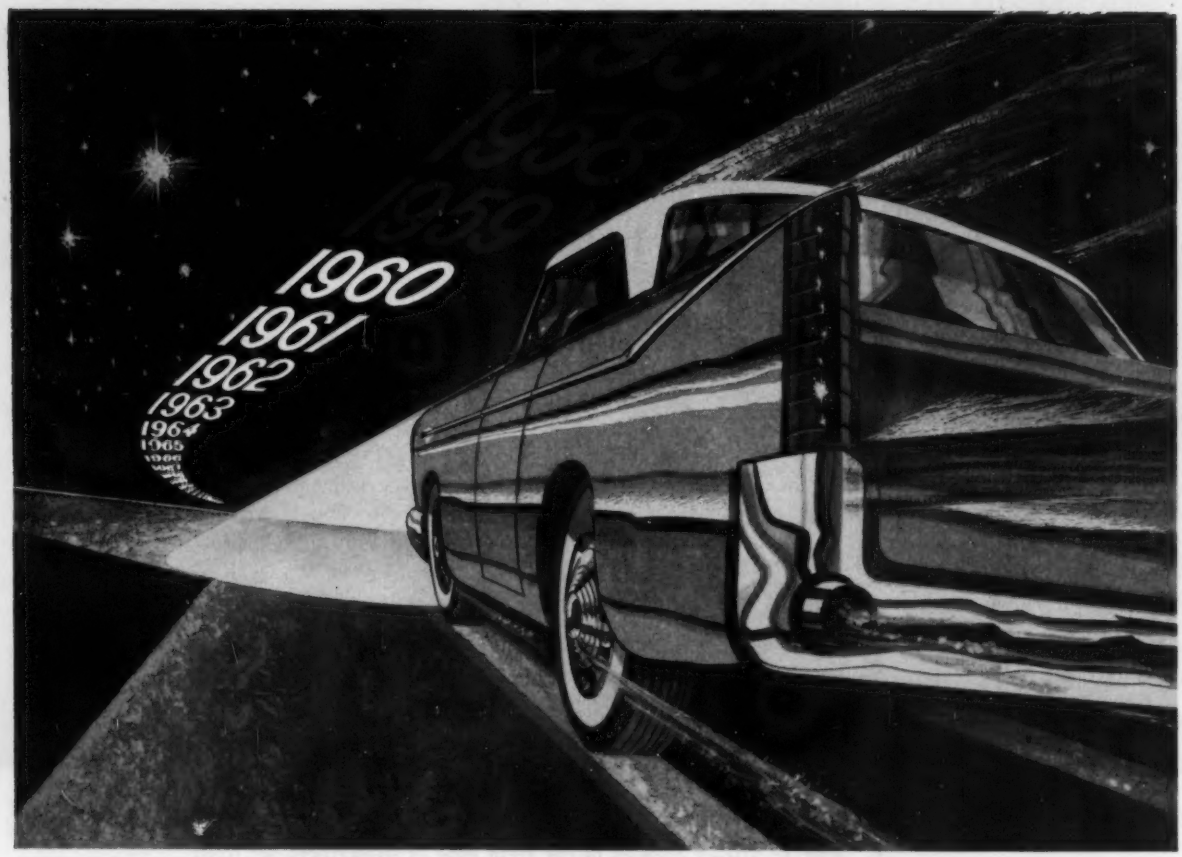
These up-to-date, audited reports help advertisers to exercise correct judgment in deciding which publications will give them the most for their advertising dollar.

When you see the ABC symbol in a publication (on Page 3 of this issue) it means that you, the reader, are the boss. And the editors know it. When we study our ABC audit report we find out in a hurry if we are earning our keep, i.e., maintaining a growing list of satisfied subscribers. This, plus increased advertising sales, is the ultimate reward for editorial initiative and leadership.

In turn, ABC circulation reports tell our advertisers what types of men, and how many, have selected PETROLEUM REFINER to keep them abreast of the economic and technical developments in the refining and petrochemical fields. To justify this selection, we must demonstrate responsiveness and a responsibility to our readers. Otherwise, we would be without our ABC membership as well as your paid subscription. And we are most anxious to keep both!

The latest ABC report shows PETROLEUM REFINER among the leaders in attracting great numbers of the right type of subscribers for our advertisers.

These are the reasons why we are proud of our ABC membership—and want you to know about it.



New Du Pont study looks into octane requirements of the future

A new Du Pont study points up the complexity of the problems you may face in planning future refinery processes and operations. Solution of these problems may depend on the answers to two basic questions:

What road octane quality can be expected from possible future gasoline compositions in tomorrow's high-compression-ratio cars?

Which of the gasolines of comparable road octane quality will be most economical to make?

Recently, some answers to the first question were found by Du Pont researchers investigating gasoline blends suitable for tomorrow's cars. More than 5,000 road octane numbers were obtained during the Du Pont study.

High-compression-ratio cars used in test

Twenty-eight representative samples from the five major refining processes in 73 different fuel blends—at 10 pounds RVP and leaded to 3 ml. per gallon—were road-rated in a fleet of cars whose engines were modified to 11.1 and 12.1 compression ratios.

With the data provided, cost comparisons can be made between blends of comparable octane quality to answer the question of maximum refining economy.

Write for free copy

Several conclusions were reached on the basis of information gathered during the Du Pont study. The complete results are now available in a paper entitled, "Road Octane Numbers of Tomorrow's Gasolines in Tomorrow's Cars." Write us if you would like a copy.

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Freedom To Grow

ON AUGUST 31 of this year one of the important international news stories of the year broke. Malaya became an independent nation.

Malaya joins the ranks of new independent Asian countries. We congratulate the people of Malaya, the government of Malaya and its rubber industry. The new Malaya has been launched in an atmosphere of friendship which should greatly smooth the transition from colonial administration to full self-government.

The importance of this event to the United States is that the U. S. gets nearly 95 percent of its natural rubber from Southeast Asia. Malaya is second only to Indonesia as the largest single source of supply, and may again become the leading exporter.

Situated in the very heart of Southeast Asia, and straddling the main trade routes from India to China, and from the Mediterranean to Australia and New Zealand, its strategic and military importance is obvious. What has been perhaps less obvious is the fact that here the three great races of the Orient, Malays, Chinese and Indians, have worked out a mode of living in harmony with Europeans which provides one of the finest examples of how different peoples can live in harmony.

The one way for the oil industry to *go ahead* and features for the rubber industry, both those who produce the rubber in Malaya and those who consume it overseas. The government of Abdul Rahman which took office August 31 is outspoken anti-communist. This is a fact which has been proven by action as well as expression in recent months.

In the second place, the new government has attracted to it a considerable number of men of proven experience and respected ability, who are not only anti-communist but are anti-extremist. They are the kind of men, and Abdul Rahman's is the kind of government, which seems likely to welcome overseas development and to insure conditions favorable to a continuing flow of development capital to Malaya. They are not the kind of men who believe in nationalization of industry, in confiscatory taxation or in narrow nationalistic preferences. And, importantly, the new government shows every evidence of being a strong ally of Western democracies in an area of the world where we need strong allies.

This transition to independence, far from threatening the life line of natural rubber from Malaya to the rest of the world, may be expected to provide excellent opportunities for new European and American investment in replantings and new plantings and should give impetus to the already launched program for smallholder replantings. In 1958 Malaya should produce more rubber than in 1957 and the cooperation between races evident in the new Malaya can be a benefit to adjoining countries who are struggling to make independence fully effective but have less experienced foundations on which to build.

A Multi-Billion Dollar Question

AMERICA's industrial and population growth has created a whopping appetite for oil—39 billion barrels of it in a ten-year period between 1956 and 1965. This amounts to 80 percent of all the crude oil produced in the 98-year history of the oil industry.

Can the industry produce that much? Can we refine that much? Yes, on one condition. The oil industry mut be allowed to operate in a climate of free competition where the tax burden is fair enough to leave adequate capital to invest in the future. This one factor is vital to the industry and the nation. Here is the reason why:

Finding the oil and bringing it to market will cost a staggering $73.5 billion. About $44.5 billion may be available from provisions covering the cost of replacing facilities that are wearing out, such as percentage depletion and charges for depreciation. Another $18.5 billion must come from earnings of oil companies. The remaining $10.5 billion will have to be borrowed from the savings of small investors all over the country.

The one way for the oil industry to *go ahead* and obtain such a sum, thus fulfilling its obligation to the nation: Permit sufficient profit to provide the incentive for others to invest in the business.

The four ways to *stop* the industry from meeting its obligations: Federal control of natural gas prices at the wellhead, continue to use oil as a political whipping boy, keep on attacking the depletion provision until it is reduced, find more ways to load the industry down with added taxes.

Go ahead or stop?

Current Demand Takes Up Slack

FOURTH QUARTER consumption of petroleum products in the U. S. is expected to show the largest gain of any period this year, the Bureau of Mines indicated in its recently revised forecast. However, the year's usage has been disappointing and will fall short of earlier expectations.

In the first nine months, domestic demand averaged 8,740,000 barrels daily, not quite 1 percent more than the 8,663,000 barrels consumed daily in the same period of 1956. Earlier estimates had the gain at 4.8 percent.

According to B. of M., fourth quarter consumption is expected to average 9,490,000 barrels daily, an increase of 5 percent over 1956's final quarter.

Instead of the 5.2 percent increase in 1957 domestic demand for oils expected by B. of M. at the year's outset, the revised forecast sees a more modest 2 percent hike over last year's record-breaking usage.

Need for all principal refined products has been disappointing. Gasoline consumption so far this year leads 1956 by 2.5 percent, and will show an increase for the year of only 3.1 percent instead of the 4.9 percent hike expected.

Ethyl Research Performance of Today's

by T. W. Warren

Director, Refinery Technology, Ethyl Corporation Research Laboratories

A premium fuel being road tested in one of Ethyl's controlled-weather rooms that duplicates road conditions exactly.

Reports on Premium Fuels

NINETY-ONE premium gasolines and 12 third-grade super-premium fuels have been tested on the road and in the laboratory in a research program recently completed by Ethyl's Detroit Research Laboratories.

The results of this investigation have been published in a 140-page report entitled "Antiknock Behavior of Premium Motor Fuels, 1957", now available to all companies in the Oil and Automotive Industries.

The fuels tested were submitted by 83 refineries of 48 American companies. These refineries produce 75 per cent of the motor fuel in the United States. Seven Canadian companies, producing an appreciable percentage of Canada's gasoline needs, also submitted fuel samples for testing.

Each Gasoline Tested 32 Times

Five 1957 cars normally requiring premium fuels, and three cars equipped with experimental 11 to 1 compression-ratio engines were used in the tests. A minimum of two Modified Uniontown and two Modified Borderline ratings were obtained for each gasoline in each car, a total of at least 32 road ratings for each fuel sample.

Extensive laboratory data, including determinations of tetraethyllead susceptibility, hydrocarbon type, and bromine number, were also obtained and are included in the report.

Test Results Point to Future Gasoline Developments

The broad sampling of premium fuels tested gave an accurate picture of today's premium gasolines and how they perform in the cars of today and in the higher compression engines of tomorrow. A complete analysis of all the test data led to the following conclusions affecting refining economics:

1. Sensitivity (the difference between Research and Motor octane number) often is an unreliable measure of road performance through the normal speed range.

2. Research and Motor octane numbers can be used to predict road performance at low speeds but are less reliable at intermediate and high speeds.

3. At higher speeds, road performance increases when the aromatic content of the gasoline is increased.

The 103 premium and super-premium gasolines in these drums were tested for Ethyl Corporation's 1957 premium fuel survey. This is the fifth premium survey conducted by Ethyl since 1946.

An important by-product of this program was the development of a system for calculating the road octane number of a gasoline. This development will permit individual refiners to determine the "road octane number" of their gasoline blends using the results of simple laboratory tests.

How Ethyl Research is helping you

Since World War II, Ethyl Corporation has investigated the laboratory and road performance of premium-grade gasolines in 1946, 1949, 1951 and 1954. During this period, the number of fuels analyzed has increased from 12 gasolines in 1946, to 63 in 1954 and 103 in 1957.

"Antiknock Behavior of Premium Motor Fuels, 1957" is one more example of Ethyl's continuing service to the Oil Industry. Copies can be obtained from your Ethyl Representative or by writing Ethyl Corporation, 100 Park Avenue, New York 17, N. Y.

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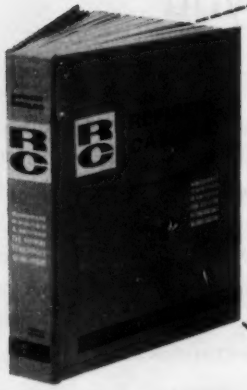

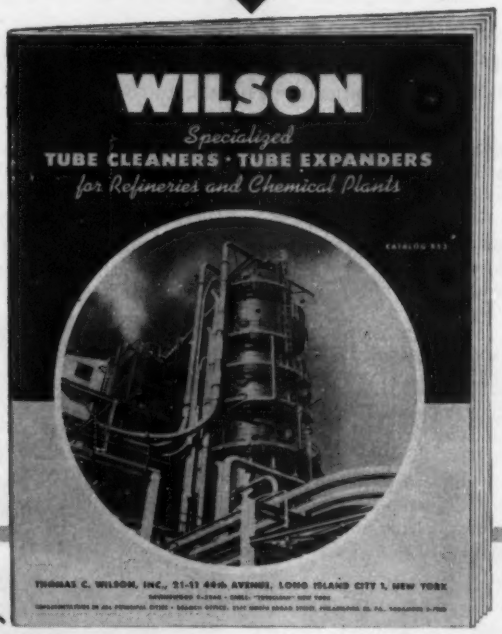
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A Special Report on Its Uses

What does natural gas mean to you? Is it just another fuel for making Btu's? Or is it a magic starting material suitable for transformation into unlimited petrochemical production?

Ethane, which can be recovered from field gas streams is currently finding its way into sales fuel gas. This highly desirable petrochemical starting material could be recovered if suitable markets were available. Is this premium product being wasted as fuel? Gas processors could supply this petrochemical raw material with only minimum additional investment. Using only the mark-up applied to high Btu gas, this venture could be profitable for all parties. This is discussed by Dudley P. Penick—"Is Ethane From Natural Gas Economical?" on Page 108.

"Who Will Pay Top Price for Natural Gas?" on Page 100 by Jack Sherred, discusses the competition of natural gas in the fuels market. In its bid for cheaper raw materials, the petrochemical industry sees serious competition for natural gas. When will it be cheaper to make chemicals from other fuels?

Natural gas competes directly in the fuels industry for residential, commercial and industrial uses. Industrial consumption continues to be the largest single user. One-third of the marketed production of natural gas is used by residential and commercial customers. The petroleum industry, in the field and at the refinery, is using less and less of the natural gas it produces. Half of the natural gas is still consumed in the states where it is produced.

Conversion into petrochemicals and intermediate products is still an attractive use for natural gas. Conversion into liquid fuels, while technically feasible, is clouded by present economics. Natural gas liquefaction, though dubious, is discussed by O. H. Simonds on Page 105.

Who Will Pay Top Price

Will natural gas price itself out of the picture? In its bid for cheaper raw materials, the chemical industry sees serious competition for natural gas.

J. A. Sherred, Monsanto Chemical Company, New Orleans

FLEXIBILITY IS one of the most amazing features of the organic chemical industry. This characteristic makes the industry unique. An organic chemical manufacturer is not firmly bound to any one raw material but can choose between agricultural products, petroleum oils, natural gas or coal as he pleases.

Neither is he bound to any one unique processing technique but nearly always has a variety of chemical reaction sequences at his disposal. Finally he finds his markets limited not only by competition from other producers of the same product but also by competition from other products.

An example of raw material competition is nylon. Today nylon is being produced from furfural, an agricultural product, from butadiene, a petroleum product and from benzene, still largely a coal product.

An example of process competition is ethylene glycol, produced commercially today from ethylene by both the chlorhydrin and direct-oxidation processes.

As examples of end-product competition, polystyrene, polyvinylchloride and polyethylene, each have overlapping applications in many areas of end use.

It is with this wide freedom of choice in mind that any examination of the economics of producing chemicals from natural gas must be approached. A decision on the part of a chemical manufacturer to base his operations on natural gas involves not only consideration of competitive raw material prices but also of alternate process costs and of end-product competition. This is doubly true today when organic chemicals are made in large, expensive, continuously operating plants which lack the flexibility of the old batch processes in their ability to change from one raw material or process to another.

The high capital investment necessitates careful study not only of raw material economics today but also what these are likely to be in the future. As will be seen later, this is an acute problem, because natural gas prices have been changing rapidly and the whole natural gas industry has been disturbed by difficult political considerations.

The important chemicals currently being made from natural gas on a large scale are ammonia, methanol, acetylene and hydrogen cyanide. For these products the natural gas is used as a process raw material. As a source of energy, either directly as fuel in process furnaces, or indirectly as fuel for steam or electric power generation, natural gas also has an influence on manufacturing costs directly proportional to the energy required to make a unit of product. Finally, any ethane or ethylene extracted from natural gas or refinery gas removes heating values that must be replaced by additional natural gas (or other fuel) and to this extent, therefore, gas prices have an effect on the price of ethylene.

Precise statistics are not available,

for Natural Gas—Chemicals or Fuels?

but our own estimates indicate that approximately 100 billion cubic feet of natural gas are currently being used each year as raw material in the manufacture of the four products ammonia, methanol, acetylene and hydrogen cyanide. This does not include the gas used to provide energy in the form of steam, electricity, etc., or for pumps, compressors, etc., incident to the manufacture of these commodities.

Likewise, due to the use of alternate raw materials such as propane for ethylene manufacture, it is extremely difficult to estimate the natural gas equivalent of the ethane used for this purpose or of the ethylene extracted as such, from refinery offgases. Present ethylene usage in the U. S. is about three billion pounds per year. If one half of this total were derived from gas streams, in the form of ethane or ethylene, this would be equivalent to about 33 trillion Btu per year or 33 billion cubic feet of natural gas.

The total usage of natural gas as raw material for chemicals, therefore, may be approximately 130 to 140 billion cubic feet per year. For comparison, sales of natural gas by pipelines were recently reported by the Federal Power Commission to be about 7.4 trillion cubic feet last year. Chemical raw material usage of natural gas therefore amounts to about 1.8 per cent of the total market.

The above estimate shows that chemical consumption, though appreciable, does not dominate or control the natural gas market and that natural gas prices are set by the conditions existing in the fuel and energy market. To the extent that a chemical manufacturer can operate profitably and competitively using natural gas at these prices, he will do so. When the profitability becomes greater by the use of other raw materials he will turn to these.

These competitive factors apply to some degree in all process industries and particularly to those which are large energy consumers. The aluminum industry is a case in point, where the production of one pound of aluminum consumes about nine kilowatt-hours of electrical energy.

The first aluminum plant was erected close to Niagara Falls to take advantage of hydro-electric power. Later expansion took place on the Gulf Coast to utilize cheap natural gas. As gas became more expensive a Pacific Northwest location became attractive, while more recent operations are being located in the Ohio Valley. One aluminum plant is even using lignite as fuel in Texas. It would seem safe to conclude from these movements that for the generation of large amounts of electricity, coal is now to be preferred over natural gas. The chemical industry is subject to analogous economic pressures.

Any study of the economics of producing chemicals from natural gas and particularly any forecast of the future therefore revolves itself into two parts. The first of these concerns the natural gas industry as a part of the over-all energy industries and the second concerns the competitive situation in the chemical industry itself between natural gas and alternate raw materials.

The natural gas industry, as a supplier of energy, is an example of an industry in which the normal economic laws of supply and demand have been considerably modified by government action. It is not entirely wrong that this should be so, particularly at the local domestic consumer level, because a householder lacks the flexibility, generally available to an industrial consumer, of being easily able to change from one fuel to another. Certainly therefore it cannot be expected that gas distribution should be excepted from the general pattern of local utilities regulations.

Over and above local control, however, the natural gas industry has been subjected to strict federal control by the Federal Power Commission as the result of the Natural Gas Acts of the late 1930's. This control involves complicated legal questions which will not be discussed here except insofar as FPC regulations have affected the price and availability of natural gas.

The main consuming areas of the country for gas lie in the east and the middle west. The main gas reserves uncovered in the past fifteen years lie in the states of Texas and Louisiana, particularly on the Gulf Coast. In order to make these reserves available to consumers, a large gas transmission industry has grown up which purchases gas in the producing fields and moves it in large volumes over considerable distances for sale to local gas utility companies for distribution, principally to commercial and domestic consumers. In the past few years this pattern has been changing to some extent as a few large distributing companies have purchased gas in the field and made transportation agreements with the transmission companies.

In order to engage in gas transmission the FPC has required that a company apply to them for a "certificate of convenience and necessity" without which interstate gas movement is forbidden. To acquire this certificate, 20 year gas purchase contracts are required (together with

evidence from a reputable, independent geologist that necessary reserves are available) also pipeline routing, costs and evidence of adequate financing. And finally, gas sales contracts at prices which allow for a utility type return on the capital invested. All subsequent changes involving expansion, price changes, etc., must be approved by the FPC.

To the foregoing abbreviated amount of FPC control over the gas transmission industry must be added the control now being exercised over gas producers which attempts to set field prices, not in accordance with supply and demand, but also on a utility-type "cost plus fair return" basis.

In order to discuss the impact of these FPC regulations on the natural gas industry, a few definitions are necessary.

Contract Price. The FPC requires that gas transmission companies purchase gas on long term, generally 20-year, contracts. These contracts provide for an initial gas price which increases stepwise by definite amounts at stated time intervals. That is, the contracts feature "time-escalation." The contract-price is the price of gas at any given time under a certain contract.

"New Gas" Price. Due to the necessity for long term contracts a considerable proportion of the present proven gas reserves is already dedicated to transmission lines. This has led to keen competition for the purchase of new gas reserves as they are discovered. The result has been that, as the transmission companies have increased their gas movements, the initial price of gas under new contracts has been greater than the price under older contracts, even though these latter have escalated with time.

Average Price. This is the average price paid for gas by a transmission company under the terms of all its purchase contracts.

Firm Gas. This refers to a gas supply that can only be cut off under restricted force *majeure* provisions such as strikes, acts of God, pipeline rupture, etc. In general, this gas is the supply to residential and commercial consumers.

Interruptible Gas. Most of the gas supplied to industry falls into this category. The contracts with the gas company recognize that domestic consumers have first priority on the supplies and that, in periods of severe weather for example, the supply to industry will have to be restricted. This can be a definite factor for industries located in the colder parts of the country. In the warmer areas and particularly in the Gulf Coast producing states, even though the industrial gas supply contracts are formally interruptible, the supply is virtually never restricted.

"Off-Peak" Gas. The incremental cost of transporting gas in a transmission system is very low and as gas demands are quite seasonal, several agreements have been made between transmission companies and large industrial consumers providing for a supply of gas at a very cheap price on a "when as and if available" basis. No guarantees are made as to quantity and the supply can be cut off on very short notice. With the development of underground storage reservoirs in the eastern part of the U.S., whereby excess gas available in the summer is stored for winter use, the amount of this gas available has been steadily decreasing.

Insofar as industry is concerned with a supply of energy, fuels are almost equivalent and can be compared on the basis of the cost per unit of thermal energy, i.e., cents/Btu. Table 1 shows cost equivalents at various gas prices, assuming natural gas with a heating value of 1000 Btu/cubic foot.

TABLE 1
Equivalent for other fuels compared to 1000 Btu/cubic feet Natural Gas

Natural Gas Cost ¢/MCF	Equivalent Value Coal ($/ton)[1]	No. 6 Fuel Oil $/Bbl[2]
5	1.30	0.35
10	2.60	0.63
15	3.90	0.94
20	5.20	1.26
30	7.80	1.88
40	10.40	2.52
50	13.00	3.15

[1] Assumes gross heating value 13,000 Btu/lb.
[2] Assumes gross heating value 6.29 MM Btu/bbl.

At present Gulf Coast prices for residual fuel oil of $2.75/barrel, the equivalent gas price is 44c/Mcf. At New York harbor price of $3.10/barrel the equivalent gas price is 49.5c/Mcf.

Coal prices vary considerably as freight costs form an important part of delivered costs. However, bituminous coal is currently selling for $5.50/ton fob mines which is equivalent to just over 21c/Mcf for gas.

These figures indicate that the use of gas for power generation or other industrial use is currently preferred on the Gulf Coast, but in those areas where coal is available, use of this fuel may be more economical. Oil has some advantages in ease of handling and initial installation costs so comparison on a Btu basis does not present a completely accurate picture.

For domestic consumers, gas has great advantage over coal and oil from a convenience standpoint, though not over electric power. For this reason a householder will pay a considerable premium per Btu for gaseous fuel or electricity. This interplay of competition can be illustrated by comparing the use of gas for domestic and industrial consumers in various parts of the country. Figures for 1954, a typical year, are shown in Table 2.

TABLE 2
Domestic and Industrial Natural Gas Sales (MMMCF) for 1954

State	Domestic	Industrial	Ratio Domestic (Industrial
Massachusetts	17.5	3.1	5.65
New York	96.0	24.4	3.93
Pennsylvania	121.9	117.2	1.04
Ohio	258.8	143.1	1.81
Virginia	15.1	16.7	0.90
West Virginia	45.8	37.1	1.23
Tennessee	20.4	48.2	0.42
Louisiana	34.1	340.5	0.10
Texas	114.6	724.5	0.14
California	265.3	310.6	0.85
Total U. S.	1783.0	3240.7	0.55
Total U.S. (excl. Texas and Louisiana)	1634.3	2157.7	0.75

The gradually increasing importance of the domestic as opposed to the industrial consumer as each is located further away from the producing states is well illustrated in Table 2.

From this we may conclude that domestic consumers have become the dominant factor in the market for natural gas as they consume over 40 percent of the gas used in the United States outside Louisiana and Texas and also that these domestic consum-

ers are willing to pay a considerable premium for gas as compared with other fuels due to its dual advantages of convenience and continuity of supply.

The history of gas prices over the past few years has been one of rapid change. The contract price is only of real interest insofar as the rate of price escalation may have changed through the years. Contracts made in 1950 generally provided for an average escalation rate of about 0.2 to 0.25 cents Mcf per year. Recent contracts show an escalation rate of about double this. This results from the fact that new gas prices have, in the past, increased more rapidly than was expected and that this rate of increase is expected to continue in the future.

New Gas Prices have been increasing at a very rapid rate. Contracts made for 1950 delivery of gas produced in southern Louisiana were at a base or initial price of about 8 cents per Mcf. The present initial prices for gas produced in the same area are about 20 to 21 cents per Mcf. This is equivalent to an increase of almost 2 cents per Mcf per year which is much greater than any time escalation increase on an old contract. However, this increase reflects both the very sharp rise in the cost of finding and producing gas and the keen competition for new reserves as they are uncovered. Most of the existing gas reserves are already dedicated to pipelines or needed for gas recycling operations.

As a result of the time escalation provisions of old contracts and the rapidly increasing starting prices in new contracts, average gas prices have been increasing rapidly. These prices are available from the annual reports of natural gas transmission companies and are shown in Table 3.

TABLE 3

Increase in Natural Gas Prices as paid by gas transmission companies

Company	Average Well-head Price (¢/MCF)	
	1950	1955
"A"	5.04	12.5
"B"		11.65
"C"	12.3	16.0
"D"	9.85	12.6

To these well-head prices (Table 3) must be added pipeline transmission costs. Distribution costs are not generally important in the supply to an industrial consumer. In the gas-producing areas, transmission costs are generally 5 to 6 cents per Mcf, so that on the Gulf Coast, for example, gas supplies are today available to industry at 16 to 18 cents per Mcf. In more distant parts of the United States costs are higher. A convenient rule of thumb is that it costs about 1.7 cents per Mcf to move gas 100 miles.

In the New York area, therefore, gas supplies to industry should cost about 40 to 45 cents per Mcf if purchase can be arranged directly from a transmission company. Actual reported costs confirm this figure. For example, in 1954, 125.4 billion cubic feet of gas were sold to industrial consumers in Pennsylvania for a total revenue of 55.4 million dollars, or an average of 44 cents per Mcf.

As a particular example of an "off-peak" gas contract, one transmission company is known to have a contract with an oil company to transport gas from the company's producing fields to its refinery in the Philadelphia area at a transmission cost of about 22 cents per Mcf. In this particular case the pipeline company does not own the gas it is transporting under the terms of the contract.

In the face of these rapidly increasing gas prices it is becoming a matter of considerable interest to examine what factors may set limits on these prices in the future. Certainly to a domestic consumer, insofar as cleanliness and convenience are concerned, electric power is equal to gas. In large cities, differences in the continuity of supply of each will be insignificant. In more rural areas, overhead power lines may be more vulnerable to breakdown due to windstorms, icing conditions, etc., than underground gas lines. It is difficult to assess how much weight should be attached to this point, as it does not seem to have been a controlling factor in the sale of domestic refrigerators which are preponderantly electrically-operated.

It can be seen, therefore, that the prices of gas and coal could differ by so much that electric power derived from coal could become directly competitive with gas. This will probably first become apparent in the wider use of electricity for cooking and hot water heating. Use of electricity for space heating is not expected to grow in the face of competition from fuel oil for this use. Certainly, at the present time, the choice of fuel exercised by a domestic customer depends more on psychological factors than economics. It will be interesting to see how long this persists as relative fuel costs become more divergent.

Before domestic consumers start changing from gas to other fuels, certain changes on the part of consumers in the producing states and of the transmission companies seem more likely.

At the present time, considerable quantities of natural gas are used for power generation. In 1955, for example, about 1150 billion cubic feet of gas were used by utility companies for generation of electricity. This amounts to about 14 percent of the total gas consumption of the United States. This is a conservative figure as the consumption of gas by industry to generate power and process steam for internal use has not been included.

If we assume that coal could be made available on the Gulf Coast for about $10 per ton, the equivalent gas price is about 33 cents per Mcf on a Btu basis. Due to handling problems, boiler design, etc., coal is slightly more expensive to burn than gas, so gas would have to rise to about 35 cents per Mcf, delivered, on the Gulf Coast to be competitive.

At a 6 cents per Mcf pipeline charge, a well-head price of 29 cents per Mcf is indicated. If the present well-head price is taken as 18 cents per Mcf and the rate of increase continues at the present rate of about 1.75 cents per Mcf per year we can expect $10 per ton coal and new gas prices to become competitive in about 6 to 7 years. With an average gas price, delivered, of about 18 cents per Mcf and a rate of increase of 1.5 cents per Mcf per year we can expect $10 per ton coal to become fully competitive in 11 to 12 years.

Obviously, this change will not occur suddenly but it is believed that, gradually, this change from gas to coal for power generation can be expected and that new installations, in particular, will use coal as fuel closer and closer to the gas producing areas.

In the past decade considerable progress has also been made in the generation of methane from coal. Extensive deposits of coal are available in states relatively close to the gas consuming areas, e.g., Virginia and Kentucky. This coal is, more-

over, readily accessible by modern strip mining methods. The proposed processing method involves:

Low temperature carbonization to give a char and low-temperature char.

Gasification of the char with steam and oxygen to yield a carbon monoxide/hydrogen mixture.

Combination of the carbon monoxide and hydrogen to yield methane.

Though some minor problems remain unsolved this processing scheme appears technically feasible. Preliminary calculations indicate that operations of this type will probably become attractive to a gas transmission company when well-head prices for gas on the Gulf Coast rise to the range of 30 to 35 cents per Mcf.

These considerations lead to the tentative conclusion that a chemical manufacturer on the Gulf Coast must face a gas price of about 35 cents per Mcf before this price starts changing in conformity with general commodity price and labor rate indices. At this time, though the current population drift westwards seems likely to continue, the main areas of end-product consumption will still be east of the Mississippi and north of the Ohio rivers. The chemical manufacturers will then face a situation where raw material (gas) costs will be lowest on the Gulf Coast but energy (electric power and steam) costs will be lowest in the coal producing areas where product transportation costs will also be lowest. There are, of course, obvious exceptions to this, e.g., for ammonia manufacture where consumption is not directly related to population density in the same manner as, say, plastics or synthetic fibers.

We can now examine the influence of a 35 cents per Mcf gas price on the manufacture of two chemical commodities, ammonia and acetylene.

The fuel and process material costs for a typical 200 tons per day anhydrous ammonia plant using natural gas and coal are shown in Table 4.[1]

TABLE 4
200 Tons/day Ammonia plant using Natural Gas and Coal

FEED	Natural Gas	Coal
Units Per Ton NH_3		
Process Gas	26 MCF	.....
Process Coal	.....	1.28 tons
Fuel Gas[1]	22 MCF	.....
Fuel Coal[2]	.....	1.11 tons
Other Costs[3]	$26.54	$28.34

[1] Includes gas for steam generation and synthesis gas compression.
[2] Includes coal for steam generation for process and compression use.
[3] Includes depreciation and local taxes, does not include profit or general overheads.

Ammonia from natural gas at 35 cents per Mcf will therefore cost about $43.34 per ton. At this ammonia price, the company producing from coal can afford to pay $15.00 for 2.39 tons of coal or approximately $6.28 per ton. This is about 10 percent greater than the current price of industrial grades of bituminous coal f.o.b. mines, so it can be expected that coal will become preferable to gas as an ammonia raw material within the next decade. It must be noted here that ammonia based on by-product hydrogen from catalytic reforming units appears to be cheaper than ammonia made from either natural gas or coal. To the extent that this by-product hydrogen is available, future ammonia plants will almost certainly use it as raw material.

When making acetylene by the Sachsse partial combustion process of methane with oxygen the natural gas requirements are shown in Table 5.[2]

TABLE 5
Natural Gas requirements for Sachsse Acetylene plant

In oxygen plant as steam	30 CF/lb C_2H_2
In acetylene plant, raw material net[1]	57 CF/lb C_2H_2
In acetylene plant, as steam	36 CF/lb C_2H_2
In acetylene plant, as fuel gas	12 CF/lb C_2H_2
Total	135 CF/lb C_2H_2

[1] Assumes off-gas after acetylene purification has same value per Btu as natural gas feed.

An increase, therefore, in natural gas prices from the current 17 cents per Mcf to 35 cents per Mcf will mean an increase in acetylene manufacturing cost of about 2.4 cents per pound.

Indications are that, today, acetylene from calcium carbide and from natural gas are competitive. The principal manufacturing cost item in calcium carbide manufacture is for electric power. To make one pound of acetylene by this method requires 3.13 pounds calcium carbide, which in turn requires about 4.7 kwh for its production.[3] All other factors being equal, an increase in gas price from 17 to 35 cents per Mcf would be equivalent to an increase in power cost of 0.51 cents per kwh for carbide manufacture.

This would seem to preclude any continuing shift to natural gas as an acetylene raw material. However, it must be stressed that the technology of acetylene manufacture from gas is relatively new and there appear to be many more opportunities for process improvement than in the older carbide technology. Further, to the extent that the acetylene plant off-gases, a mixture principally of hydrogen and carbon monoxide, have a value greater than natural gas when used for, say, ammonia or methanol manufacture, the economics of manufacturing acetylene from natural gas are rapidly improved.

It will be extremely interesting to see whether, in the future, improvements in the technology of making acetylene from gas can keep pace with the increasing price of the natural gas raw material.

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What's Ahead for Gas Liquefaction

Continuing interest in natural gas liquefaction indicates that commercial installations may come soon. However, economic justification is still paramount.

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IN THE PAST decade considerable thought and study have been given to commercializing the inherent advantages of liquefaction in the storage and transportation of natural gas, but to the best of knowledge not a single application has been effected, unless it be one in the USSR, announced in 1947, of which little, if anything is known.

The foresight, pioneering work and courage of those responsible for the classic liquefied natural gas storage installation at Cleveland of the East Ohio Gas Company in the early 1940s and the experience gained there should not be lost. The final outcome was tragic but, quoting from Report of Investigations by the U. S. Bureau of Mines "Regardless of the cause of the disaster . . . the application of the system for liquefying and storing large quantities of natural gas is *not* invalidated, provided proper precautions are observed." (emphasis supplied)

One project for the construction of a liquefaction, storage and regasification plant, about twice the size of Cleveland, advanced as far as the issuance in 1949 by the Federal Power Commission of a certificate of convenience and necessity, but subsequently the certificate was revoked at the request of the applicant because of the discovery, close to the market, of a geologic anticline or trap having a stratum of permeable water-bearing sandstone or limestone, which could be used for the development of aquifer storage of natural gas more economically and in much larger volume than practicable by liquefaction.

More recently there has been a pronounced revival of interest in the subject and substantial expenditures have been made in an effort to improve upon the Cleveland design of liquefaction and storage by taking advantage of advances in the art during the intervening period, especially in metallurgy and insulation.

Application. The two fields of application for the liquefaction of natural gas which are most important and wherein lies the greatest opportunity are—

1. In large volume storage of natural gas close to a major market where depleted gas and/or oil fields, or aquifer storage are not available, and

2. In the transportation by barge or tanker of natural gas from source of supply to market where it is not practicable to transport by pipe line.

The great development in underground storage of natural gas in the United States has eliminated a number of potential situations where storage of liquefied natural gas might have been considered advantageously, and similarly, the extension of natural gas pipe lines to practically all market areas in the United States has largely eliminated, except possibly in specific situations, the occasion to transport liquefied natural gas on the inland and coastal waterways.

Under these conditions, what are the possible applications for natural gas liquefaction?

It is believed that there are—

1. Still a limited number of large natural gas markets in the United States which are not blessed with de-

pleted gas fields or conditions suitable for aquifer storage, where liquefied natural gas storage might be advantageous, and

2. Opportunities in the free world to supply natural gas, for reforming, to markets presently served with manufactured gas, or for use directly in chemical manufacture, by the transportation of liquefied natural gas in tanker or barge from areas having flare gas from oil production, or from dry gas fields not having markets which could be reached by pipe line.

Liquefied Natural Gas Storage. As respects gas storage, the primary purpose, whether it be depleted gas fields, aquifer, high pressure pipe, steel 'bottle' or liquefied, is to provide gas supply during periods of abnormal or peak demands. A collateral advantage to this is, of course, that by storing gas during the non-peak periods the annual load factor of gas purchases is improved.

In the absence of gas storage of any kind, other than in above-ground holders to meet hourly fluctuations in load, there are a number of methods or processes in use to produce a substitute for natural gas to meet abnormal or peak period requirements, e.g.,

Thermal cracking of light or heavy (#6 residual) oils; propane-air and catalytic reforming of LPG.

Storage of LPG would be in pressure tanks, refrigerated storage or cavern storage.

Although generally, depleted gas fields are considered to provide the most economical form of large volume storage, with aquifer storage and liquefied storage following in that order, the relevant factors of each particular situation must be analyzed in detail in order to determine which type of storage or process for the production of a substitute for natural gas would best meet the requirements of the particular situation under review.

Liquefied Natural Gas Transportation. As respects the transportation of flare or waste gas to markets not having access to natural gas, the most obvious market is England, Scotland and Wales (with a population of 50 million). Here, manufactured gas is supplied by The Gas Council, i.e., the nationalized gas industry, through a rapidly growing gas grid. There are some 12 million customers, predominately residential, a ratio of 1:4.25 of population, as compared to the corresponding ratio of approximately 1:5.6 of population in the U.S. There are other similar, although perhaps not as large markets, throughout the world now dependent upon manufactured gas.

Sir Harold Smith, K.B.E., chairman of the Gas Council of England, stated in an article appearing in *Financial Times* as recently as May 14, 1957, that "it is obvious from the statement of the Paymaster General that we have to look to raw materials other than coal for developing gas production." Then, after describing various processes under consideration, including the gasification of heavy oil residual, he states:

"In addition to the search for natural gas a very comprehensive survey has been made of the possibility of importing natural gas in the form of liquid methane. Liquefying methane reduces its volume to 1/600th of that it occupies as a gas, but to do this the temperature of the gas has to be reduced to —260F and maintained at that figure throughout transportation. The technical problems involved are many and complicated, but these are well on the way to being solved and, subject to the importation of the product being permitted under the balance of payments arrangements, a trial might now be considered probable rather than possible. The same advantages will apply to the use of liquid methane as to the gasification of oil, namely, lower capital, less labour and a reduction in cost of gas production."

The holder costs per therm for manufactured gas produced and purchased by The Gas Council in England in the twelve months ended March 31, 1956, averaged 9.42d. (US$0.1099) and ranged from 6.88d. (US$0.0803) to 11.12d. (US$0.1298).

The present costs are probably somewhat higher due to increases in the cost of coal and in the Scandinavian and other European countries the holder cost of manufactured gas may be still higher than in England due to a gas-coal c.i.f. cost of between US$20 and US$25 per ton.

Investment Costs. In 1949 the estimated cost of a liquefaction plant of approximately 5 million cubic feet per day capacity; 400 million cubic feet storage and a regasification rate of 6 million cubic feet per hour was $5 Million, exclusive of land, fencing, pipe lines, office, laboratory, repair shop, roads, sewers, septic tank, yard improvements, contractors' profit and miscellaneous, divided approximately as follows:

	Percent
Liquefaction Equipment	25.9
Storage	57.1
Regasification	17.0
Total	100.0

More recently the estimated cost of a liquefaction plant of three million cubic feet per day capacity, 600 million cubic feet storage, and three million cubic feet per hour regasification capacity, was $3,720,000, exclusive of the same items as above, divided approximately as follows:

	Percent
Liquefaction Equipment	18.8
Storage	74.2
Regasification	7.0
Total	100.0

The difference in the above estimates as between the investment cost of liquefaction, storage and regasification facilities, to the total may well be due to the difference in the capacity of the three situations and to the classification of common or joint facilities and is not important. Suffice it to note in an installation where the availability of storage for use during periods of peak demand is the underlying purpose, the capital cost of storage is a major portion of the total investment.

Marine transportation of liquid methane presents both a financial and an economic problem. Financial, because of the generally long distance between points of liquefaction and regasification involving large investments in transportation facilities. Economic, because of the greatly increased cost of a tanker over that of the conventional oil tanker, due to the necessity of using high alloy steel, high alloy copper or aluminum tanks to withstand the low temperature of the cargo insulated from higher temperatures of surrounding atmosphere, as well as the impossibility of loading the tanker to its full draft line because of the buoyancy of the product. Foreign construction of the tanker as well as foreign flag registry may be advan-

tageous in reducing both investment and operating costs.

The cost of natural gas delivered to liquefaction plant may well be the governing factor but if a cost of $0.005 to $0.010 per therm is a reasonable assumption, the spread between such a cost and the holder cost of the manufactured gas to be replaced or supplemented, of say $0.08 to $0.10 per therm, would seem to be sufficient to encourage detail studies of the subject.

In a recent very comprehensive article by Lederman and Williams,[1] the division of investment of a much larger operation than either of those cited above, was as follows:

	Percent
Liquefaction Equipment	41.4
Tankers	33.0
Storage Tanks	13.0
Regasification Plant	1.7
Docks	1.7
Contingency	9.2
Total	100.0

In the above, the ratio of capital cost of storage to total investment is materially reduced because base load supply of gas rather than peak supply is contemplated and due to the effect of large investment in transportation facilities.

In this article[1] the increase in fuel requirements of the free world is stressed, and also that even today the technology is available which will allow the transportation of liquefied natural gas to satisfy these requirements in competition with other fuels or forms of energy.

In considering the use of liquefied natural gas for either storage for peak period demands or for transportation, the cost of the service must of course be no greater and preferably lower than that of the alternate processes and methods referred to above.

Design Improvements. Liquefaction in both the Cleveland plant and in the project approved by Federal Power Commission, but subsequently dropped, was provided by the basic Keesom Cascade refrigeration cycle using propane and ethylene as refrigerants. Possible improvements would be through the use of centrifugal compressors and of turbo-expanders cooling and liquefying the gas in a series of stages. These improvements are important but would not materially reduce the investment and operating costs.

The principal opportunity for a reduction in the initial investment would seem to lie in an improvement over the proved design of a low-temperature spherical holder comprising two concentric spheres insulated from each other. In order to withstand temperatures of —260F the inner sphere has been of high nickel alloy steel. Other alternatives are, of course, copper nickle alloy, aluminum or other alloy with adequate strength and impact resistance at the low temperature. It is to be hoped that through research and the use of newly developed insulation material, plastic or otherwise, it may be possible to make use of some less expensive material for the inner sphere by placing insulation on the inside in direct contact with the low-temperature liquid. This could alleviate the necessity of using the expensive high alloy materials. The use of balsawood has already been considered for this purpose and other alternates may be obtainable.

For large volume storage there have been suggestions of an insulated concrete basin or reservoir and also cavern storage, depending upon the surrounding frozen earth for insulation, and having for a roof a geodesic dome of interlocking aluminum panels, insulated and free of all central supports. Cavern storage would seem to be the cheaper but there may be a question as to the ability of any rock formation to withstand the effect of low temperatures.

Any improvement in the design of above-ground storage for low temperature liquids, would, of course, be equally applicable to storage tanks on tankers for transportation of liquefied natural gas.

Recovery of Refrigeration on Regasification. A very important factor in the economics of liquefaction is that of using the great quantity of 'cold' available from the regasification of the liquid methane. The profitable use of this refrigerant or 'by-product' may well be the difference between profit and loss of the entire project.

A rather obvious use of this 'cold' is for direct refrigeration, such as large meat packing, cold storage or food freezing plants. Unfortunately, these plants may not always exist at the point of regasification.

What other uses might be considered?

One would be to produce oxygen in large volume for use in the steel industry if tank car or barge transportation is available and feasible, for delivery to the point of use from the regasification plant. Another large volume applimation for oxygen would be in water-gas manufacture, where the use of oxygen would result in considerable saving of fuel either in the use of inferior fuel or a smaller amount of premium fuel, in addition to providing increased capacity and a lower cost of labor for operation and maintenance. This application would seem to have possibilities where the regasified liquid methane is to be reformed to supplement manufactured gas. There are undoubtedly other applications for large volume supply of oxygen as well as other uses that can be made of the mass of 'cold'.

In summary, there would seem to be a sufficient number of potential applications for the use of liquefied natural gas to justify continuing research to improve more particularly the design of low-temperature storage, as well as to develop uses for the 'by-product' 'cold' resulting from the regasification of the liquid methane.

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About the Author

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NATURAL GAS

Is Ethane From Natural Gas Economical?

Ethane recovery is good business because of the moderate investment, quick payout and the possibility of good materials.

Dudley P. Penick, Magnolia Petroleum Company, Dallas

ETHANE, present in the field gas of many processing plants in large amounts, is a valuable petrochemical raw material. However, very little ethane is recovered for this purpose. Most of the ethane goes to residue gas or is used as plant fuel. Consequently the producer and the processor receive no premium over the residue gas price for the ethane.

Actually, the small amount of ethane recovered along with propane and other products presents a processing problem in returning it to the gas stream. A few plants now sell this ethane, but more would be sold if attractive markets could be developed.

This "recovered" ethane represents only a small fraction of the total ethane entering the plant. Additional investment and operating costs would be required in both existing and future plants to recover larger fractions. The value of ethane as a petrochemical raw material must be sufficient to justify these costs, before processors would install the facilities to make these large potential supplies of ethane available.

Natural Gas—A Potential Ethane Source. How much ethane is contained in the gas processed by a "typical" plant? A glance at Figure 1 shows there is no such thing as a typical plant. The ethane content depends on the volume processed and the gas analysis. These variables are shown in Figure 1, with points plotted to indicate the ethane content for a cross section of plants from the author's experience. Ethane content of raw natural gas will vary from a minimum of about two percent to a maximum of perhaps 20 percent in rare cases.

An interesting comparison is the possible ethane contents of individual gas processing plant feed streams with the requirements of petrochemical operations.

An ethylene plant utilizing ethane as its sole raw material with capacities of 100,000,000 to 300,000,000 pounds per year would require approximately 4.7 to 14 Mmscf/day of ethane, assuming a representative weight yield

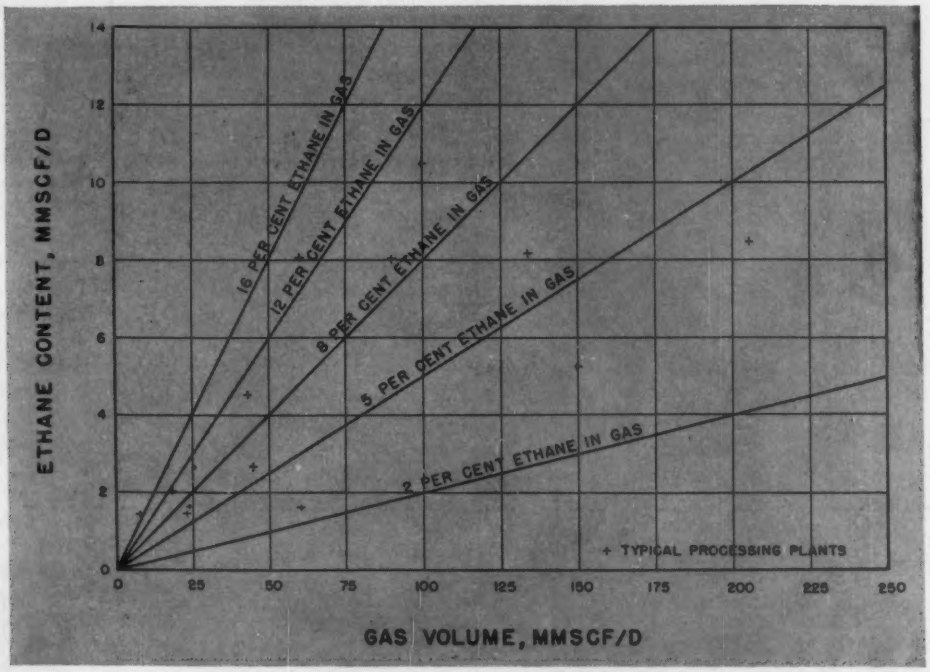

FIGURE 1—Ethane content of natural gas showing ethane recoverable for various concentrations. + marks indicate the ethane content for a cross section of plants from the author's experience.

of ethylene on ethane of 75 weight percent.[3] Figure 1 indicates that a plant processing 40-50 Mmcf/day of high ethane content gas, or larger volumes of lower ethane content gas, could produce enough ethane for a minimum size ethylene unit (100,000,000 pounds per year) if the plant were designed for high ethane recovery.

Even with a lower ethane recovery, a few of the larger gas processing plants could supply sufficient ethane for a petrochemical operation. In many cases two or more plants in the same general area could be used as suppliers of ethane for a single ethylene plant.

If a mixture of ethane and propane or with propane and butane were used as ethylene raw material, then relatively smaller gas processing plants could supply the requirements of a given petrochemical operation. For example, a 100,000,000 pounds per year ethylene plant might require[3] about 150,000 gallons per day of a mixture containing 40 percent ethane and 60 percent propane by volume. The ethane portion of this mixture would be equivalent to about 2.4 Mmscf/day.

A raw material such as the above could be produced by a gas processing plant with considerably less investment and operating cost than a high purity ethane product. The price for the ethane portion of the mixture could in most cases be lower than the price of high purity ethane, providing the processor had a firm contract for sale of the ethane before installing the necessary production facilities. An ethane mixture raw material would offer other advantages to the petrochemical manufacturer in the transportation and storage of his raw material. If propylene is also required along with ethylene, he may prefer such a feed stock.

The present disposition of ethane in most plants must be known in order to evaluate the value of ethane to a gas processor. The major portion of the ethane in the feed is not recovered as a liquid in the absorption or refrigeration recovery section of the plant. This portion remains in the gas, and as plant residue is either sold to a transmission line or utilized on the producing leases.

In an absorption or refrigeration plant designed to recover propane and heavier products, a certain amount of ethane, and also methane, will be recovered as a liquid in the initial recovery step. Some of this "recovered" ethane remains in the plant propane product, usually less than five percent of the volume of propane recovered. Unless ethane is sold as a plant by-product, the rest of this "recovered" ethane must be removed from the plant liquid stream and returned to the gas stream.

This is done by several processing methods. Various reabsorbers, product deethanizers, rich oil deethanizers, and other types of equipment are used. The ethane ends up as a constituent of the gas stream from these units, usually at a lower pressure than the gas from the initial recovery step. The amount and concentration of ethane in these streams is dependent on the individual plant process. In a few plants these streams have been sold as a petrochemical raw material, due to their high ethane content.[1] In these cases, the operation of the plant may be changed somewhat in order to increase the ethane volume or concentration in the by-product streams.

If these streams are not sold, to save recompression cost, they are used as plant fuel. Due to their higher heating value less volume is required resulting in a larger volume of plant residue. This is an important consideration if the residue gas is sold with no heating value premium.

The current return on ethane to most gas processors is its value as residue gas. This is fixed by the gas sales contract or the value to the producer for lease uses. If no heating value premium is given, then ethane is no more valuable in the residue gas than methane, or any other constituent. If a heating value premium is given, or if the ethane content is necessary to raise the heating value above a specified contract minimum, then the ethane is a little more valuable. Most heating value premiums raise the price in direct ratio to the Btu/SCF over 1000. Ethane (heating value about 1780 Btu/SCF), in these cases is worth, to the processor, approximately 1.8 times the base gas sales contract price per MCF of residue gas.

The value of ethane sold as a by-product would be fixed by the individual sales contracts. One such contract for the sale of an ethane-rich gas[1] calls for 50 cents per MCF for the ethane and any heavier constituents, and residue gas value for the methane portion. Higher prices have been mentioned in other contract negotiations. The price paid will of course depend on the form in which the ethane is delivered.

Processing Plant By-Product. It is difficult to generalize on the percent ethane recovery obtainable by processing plants on a by-product basis. Perhaps the major process design differences of these plants are in the method of limiting the by-product recovery in the primary step (absorption or refrigeration) and in separating the recovery ethane from the desirable products. Sale of by-product ethane results in a radical change in the general process design philosophy. Precautions which ordinarily would be taken to reduce primary ethane recovery would be discarded, and the opposite effect sought. The purification step becomes one of demethanizing rather than deethanizing.

Figure 2 shows the range of fair purity ethane recovery in conventional plants, as a function of the plant propane recovery. This is the portion of the total ethane that could usually be made available as a by-product with little investment by the processor. As described above, these recoveries have in some cases been increased somewhat by various changes in operating procedures and conditions. Most plants falling in the lower portion of the range could be increased somewhat. The amount of increase possible is dependent on the individual plant process. In one case where this has been done, the ethane recovery was approximately doubled.

By mixing reabsorber vapors with the higher purity ethane streams, more ethane could be made available, but it would be more contaminated with methane and propane. Ethane content might be as low as 30-50 percent, as compared to 70-90 percent for the higher purity streams.

Therefore it is obvious that if only by-product ethane is to be used as an ethylene raw material, very few individual gas processing plants would recover enough to supply a minimum-size ethylene plant. Contracts with several plants in a given area will almost always be necessary, but existing plants will usually be in a position to make such a sale.

Some consideration should be given to the form in which the by-product

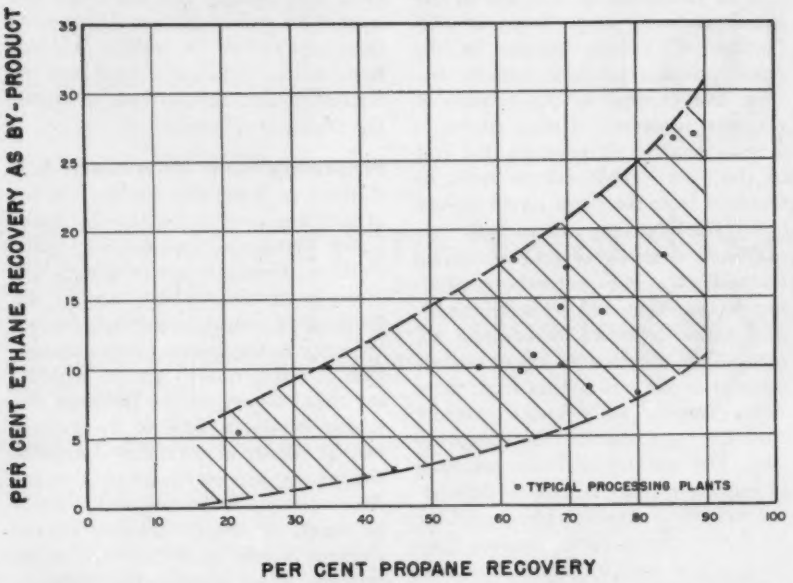

FIGURE 2—By-product ethane recovery as a function of propane recovery. The shaded area indicates the portion of ethane that could be recovered with minimum investment.

ethane is available. Pure ethane has a critical temperature of 90.1 F. and a critical pressure of 708 psia.[4] The by-product ethane from gas processing plants will be in the gaseous state, and usually is at pressures below 500 psi. Compressors could be installed to deliver the ethane at any desired pressure, but it would be practically impossible to deliver a liquid product because of the low critical temperature.

Such a product must usually be transported by pipe line, and cost storage facilities would be prohibitive in cost. As far as the processing plant is concerned, the ethane must be delivered when it is made, or not at all. Another potential means of transportation is as a liquid at atmospheric pressure, utilizing insulated barges such as those which have been proposed for transporting liquefied natural gas.

Usually the settlement for an ethane by-product will be based on volume and composition. Some type of sampling and analysis system must be used to determine the composition. Measurement by conventional methods is possible, but special data may be required to accurately evaluate the compressibility of a given mixture. Also, precautions must be taken to see that measurement conditions are such that no condensation will occur.

In order for the sale of by-product ethane to be attractive to the gas processor, the selling price must cover the following:

- 1. The current value of the ethane, usually as residue gas.
- 2. The value of any fuel which is used to make the ethane available for sale.
- 3. Any additional operating expenses resulting from the ethane sale.
- 4. Depreciation on any investment required.
- 5. Payments to the gas producers under the gas contract on which the processor obtains his gas.
- 6. An attractive profit.

It is clear that as the value of residue gas increases, the value of by-product ethane must also increase, particularly if a heating value premium is involved. Most residue gas sales contracts have price escalation provisions, so it would be realistic to allow for this in the ethane sales contract. As previously discussed, a heating value premium will increase the ethane value by a factor of about 1.8.

Sale of by-product ethane will result in the use of some additional fuel, which otherwise could be sold as residue gas. This fuel is used primarily to dehydrate the ethane and compress it to the required sales pressure.

Usually the major additional investment and operating costs involved in marketing by-product ethane will be in the dehydration, compression, and settlement facilities. The processor may also make additional investment in equipment to increase the amount of ethane available for sale.

Sale of by-product ethane will usually increase the processors gas cost. The usual purchase contract calls for payment on the basis of the return received from the gas, and the various products recovered from it. Ethane is usually covered by an "additional products" section of the contract, which calls for a fixed percentage (often 15 percent) of the gross proceeds to be paid to the producer.

All the above items must be recovered by the processor from his by-product ethane sales income in order to break even on the sale. He would, of course, expect to receive some additional income as profit and as return for his investment risk. It would be impossible to generalize as to just how much per MCF by-product ethane should be worth, since the above factors could be greatly different in various plants.

Beeson[1] has given an illustration based on 50 cents per MCF for the ethane and 12 cents per MCF with heating value premium for residue gas. The figures indicate that such a sale would be attractive if no appreciable investment and operating cost were involved, but that any such costs would reduce the attractiveness of the sale to the processor. The heating value premium in this illustration could be the difference in making the sale attractive to the processor. Ethane at 50 cents per MCF is equivalent to less than two cents per gallon, so it would be a cheap petrochemical raw material in comparison to propane or butane.

Processing Plant Primary Product. Predictions indicate ethane will play an increasingly important role as a petrochemical raw material. Natural gas is the largest available potential source of ethane, but in order for gas to supply large amounts of this raw material facilities specifically designed to recover ethane must be installed. It may well be that gas processors will eventually look at high ethane recovery in the same way that they now look at high propane recovery. If a sufficient market exists for the propane, it is usually a good investment to install a more costly plant to re-

cover a higher percentage. The same can be true of ethane.

This is particularly true in the case of new plants to be built in the future, although redesigning existing plants to recover ethane is also possible. However, it would probably be less expensive to install the recovery facilities in a new plant than in an existing plant. This same situation occurred with propane a number of years ago when the first new plants were designed and built for high propane recovery. After these had been built and the market developed somewhat, many older plants which had been recovering propane only as a by-product were revamped to give higher propane recoveries. Ethane recovery might well follow the same pattern.

The design of a plant for high ethane recovery will be greatly influenced by the form in which the ethane is to be recovered and transported. The most satisfactory type of product would be a mixture of ethane and propane. Such a product would be more economical to manufacture, store, and transport, since it would be a liquid product. An ethane-methane mixture (with small amounts of propane) could also be manufactured comparatively easily, but it would have to be transported as a gas and storage would be difficult. A high purity (90 percent or more) ethane product would be much more expensive to manufacture, and therefore would require a higher price. Storage and transportation difficulties would also be encountered with such a product.

In gas processing plants using an absorption process, the amount of absorption oil to be circulated is usually fixed by the propane recovery desired, and the ethane recovery is considerably less than the propane recovery. For an average absorber operating at typical pressure and temperature conditions (with no refrigeration of gas or oil), absorption of 80 percent of the propane from the inlet gas results in the absorption of about 33 percent of the ethane and 8 percent of the methane. For the same gas and conditions, about 2½ times as much oil would have to be circulated to absorb 80 percent of the ethane. With this oil rate, propane would be about 99.5 percent absorbed, and about 22 percent of the methane would also be absorbed.

An absorption plant to recover 80 percent ethane would cost at least 75 percent more than a plant to recover 80 percent propane, due to the large oil circulation increase necessary. Also it would probably be necessary that the ethane from such a plant be produced as an ethane-methane mixture. For these reasons, other recovery processes are perhaps better suited to high ethane recovery.

Recovery processes using refrigeration obtain the same effect as raising the oil rate by chilling the gas stream to a lower temperature. However, the additional recovery often is more selective in a refrigeration process resulting in lower methane recovery. The temperature necessary to obtain a given ethane recovery will of course be dependent on the gas composition and pressure, but it is likely to be quite low for many gas streams. Dehydration of the gas and liquid streams is an important consideration in such a plant. This process can give high ethane recoveries from fairly rich gas streams at temperatures which can be obtained economically.

For leaner gas streams much lower temperatures would be required and a combination refrigeration-absorption process will usually be more economical. In such a process, the gas and absorption oil are chilled before entering the absorber, which operates at a low temperature. Temperatures as low as —10 F might be possible.

A somewhat different type of refrigeration process has been proposed as a means of obtaining high propane and ethane recoveries. The process is based on the same principles utilized in oxygen plants for the separation of oxygen and nitrogen. It involves regenerative refrigeration through direct gas to gas heat exchange, and utilizes the Joule-Thompson effect in revaporizing the condensed liquids by reducing the pressure. Carried to its extreme, this process would be a gas liquefaction process. It could be designed for any desired recovery by controlling the temperature to which the gas is chilled. Temperatures as low as—150 to—200 F. might be used.

As far as is known, no plant of this type has yet been built for natural gas liquids recovery. However, the process would probably be quite attractive if a high ethane recovery were desired. The process has been utilized in other industries.

Another process which has been proposed for high ethane recovery is the hypersorption process.[2] This is a process for the continuous separation of gases by selective adsorption on a moving bed of activated carbon. This process has also been utilized in other industries, but as far as is known, not for natural gas liquids recovery. It is possible that other adsorption type processes could also be used for ethane recovery.

Little work has been done on the design of gas processing plants for high ethane recovery due to lack of economic incentive. No doubt many problems will arise when this engineering problem is undertaken, resulting in a variety of solutions. The major problem will be recovery of ethane without excessive methane recovery or contamination. This is a parallel to the present problem of separation between propane and ethane. Also adequate basic design data, such as equilibrium and enthalpy data, at the design conditions is unavailable. Design temperatures and pressures

About the Author

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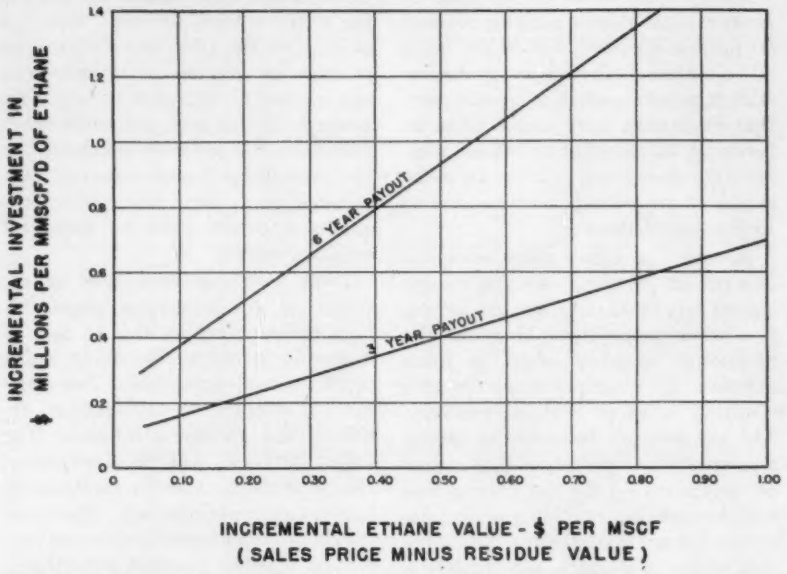

FIGURE 3—Shows the approximate economics for the recovery of ethane as a primary plant product. The incremental investment for ethane recovered is shown for 3 and 6 year payout.

encountered in these plants will be more critical regions than those now commonly used.

How high a percentage ethane recovery is economically justified will depend on the sales value of the ethane. Essentially complete recovery is possible by some of the methods discussed, but probably not economically feasible. Perhaps 70 to 85 percent recovery would be the realistic upper limit. Therefore many individual gas processing plants could supply the raw materials for an ethylene plant. This is particularly true if a mixture of ethane and propane, and also butane, is a desirable raw material.

In studying the economics of high ethane recovery, the gas processor should compare the incremental recovery of any process under study to what he considers optimum design for propane recovery. It is the incremental investment and operating costs which he must justify. If the high ethane recovery plant recovers more propane and other products than the optimum propane recovery plant, then the income from those additional products, as well as the ethane sales income, should be credited toward paying out the incremental investment.

Figure 3 illustrates the approximate incremental economics of the recovery of ethane as a primary plant product. It shows the investment a processor could afford to make per MMscf/D of ethane recovered for three year and six year payouts as a function of the increase in ethane value. For example, if the ethane can be sold for fifty cents per Mscf, and the residue gas price is 15 cents per Mscf with a heating value premium, the increase in ethane value would be approximately 50 — (1.8) (15) = 23 cents per Mscf. At this price the processor could afford to invest about $240,000 per MMscf/D of ethane recovered if he wants a three year payout, or about $560,000 if he would be satisfied with a six year payout.

Figure 3 is based on certain assumptions and approximations. It was assumed that for every MMscf of ethane recovered as a product, 0.2 MMscf of additional propane or heavier products would be recovered over the "optimum propane recovery" plant being used as a basis for comparison. These additional products were assigned a value of $1.10 per Mscf, which is equivalent to four cents per gallon for propane. This will account for the fact that Figure 3 indicates a small investment could be paid out even if the ethane has no incremental value.

Operating and maintenance expenses were assumed to be $50 per MMscf of ethane product. Fuel requirements were estimated to be four percent of the volume of ethane, and the fuel was assumed to be valued at 25 percent of the incremental ethane value. A depreciation rate of eight percent and an income tax rate of 52 percent were used.

Instead of the above assumptions, the particular facts relating to any given situation could be used to prepare curves such as those in Figure 3 for any gas processing plant. The above assumptions were made only to give some idea of the approximate investments a gas processor could afford to make for ethane recovery.

It has been estimated that a 200,000,000 pounds per year ethylene plant using a 40:60 ethane-propane mixture as raw material would require the equivalent of about 5 MMscf/D of ethane and 180,000 gallons per day of propane. If we assume that a gas processing plant or group of plants could potentially recover this amount of ethane and propane, then the limiting investments for 5 MMscf/D of ethane shown in Table 1 are obtained from Figure 3.

TABLE 1—Maximum Investments for 5 MMSCF/D of Ethane

Incremental Ethane Value	3 Year Payout	6 Year Payout
40¢/MSCF...	$1,700,000	$3,950,000
60¢/MSCF...	$2,300,000	$5,350,000
80¢/MSCF...	$2,900,000	$6,750,000

The actual investment required to recover 5 MMscf/D of ethane depends on the individual plant in question. It seems quite probable however on the basis of Table 1 that many plants could install such facilities at attractive investments. The only incentive needed by the gas processor is for the petrochemical manufacturer to offer a contract to purchase the ethane.

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Multicomponent Flash Calculations

Another new method for flash equilibrium to save you time over the regular trial-and-error methods.

James B. Bachelor
Holmes and Narver, Incorporated
Los Angeles

FLASH EQUILIBRIUM calculations considered here are those required to determine the extent of vaporization in a multicomponent mixture of two or three phases of fixed total composition, pressure and temperature. Such calculations are so often required in chemical process design that any reduction or simplification of the calculation steps is of real value. For this reason, a number of useful methods have been contributed to aid in the calculation of the two-phase equilibrium problem.[2-13] Some are recommended for digital computer programming.

Actually the calculation steps can be reduced and simplified still more by a new method. Several terms in the familiar Taylor series expansion are used to represent the flash function in the region of a vaporization point. Unlike other methods of this type, the first three terms of the series are used instead of two.

Some other methods sacrifice really rapid convergence by a transformation which extends the range of convergence. To get around this problem, in this method the range is located by two very simple limiting equations which apply very accurately at close to maximum and minimum vaporization points. Flash equilibrium calculations in these limiting ranges have generally been the most troublesome.

The limiting equations either accurately establish the vaporization point in a limiting range or indicate the approximate extent of vaporization. The solution is completed in the indicated range at a vaporization point designed to simplify the arithmetic compared to that usually required.

The method is applicable to the usual two phase and also the three phase equilibrium problem encountered when one of the condensed components is only relatively soluble in the main bulk of condensed liquid. A later

article will describe the application of the method to the more general though less common and more complicated case of mutual solubility in multiphase equilibrium mixtures.

Basis. The basic flash equilibrium equation is well known and may be written in terms of components in the liquid phase or vapor phase as shown below. The equations are written to include a condensible component I, with limited solubility which may exist in a second liquid phase that contains negligible quantities of the other components.

$$\sum_{i=1}^{n} l_i = L = \sum_{i=1}^{n} \frac{m_i}{\frac{\Sigma m_i - L}{L} K_i C_L + 1} = \sum_{i=1}^{n} f_i\,(L) \qquad (1)$$

$$\sum_{i=1}^{n} v_i = V = \sum_{i=1}^{n} \frac{m_i K_i}{\frac{\Sigma m_i - V}{V} C_V + K_i} = \sum_{i=1}^{n} f_i\,(V) \qquad (2)$$

When $\frac{l_i}{L} \leq S_i$, $C_L = 1$ and sum is over $i = 1, 2, \ldots, \ldots, n$.

If when $i = I$, $\frac{l_I}{L} > S_I$, $C_L = \frac{1 - S_I}{1 - S_I K_I}$ and sum is over $i = 1,2, \ldots, n$. $i \neq I$

When $\frac{m_i - v_i}{\Sigma m_i - V} \leq S_i$, $C_V = 1$ and sum is over $i = 1,2, \ldots, n$.

If when $i = I$, $\frac{m_I - v_I}{\Sigma m_i - V} > S_I$, $C_V = \frac{1 - S_I K_I}{1 - S_I}$ and sum is over $i = 1,2, \ldots, n$. $i \neq I$

The term $1 - S_I K_I$ in C_L and C_V may be replaced by the equivalent term $1 - P_I/\pi$. When S_I is very small the term $(1 - S_I)$ naturally reduces to unity, however this is not true for $(1 - S_I K_I)$ since K_I might become very large.

Observing these equations it may be seen that when the solubility of the relatively insoluble component is not exceeded in the condensed phase, the equations reduce to their usual form and the summations proceed over all components. When the solubility of the relatively insoluble component is exceeded in the main condensed phase then the equations shift to a different form and the summation does not include the relatively insoluble component. The first numerical operation will always be performed on the relatively insoluble component so as to determine which form of the equation to apply.

Equations of the type above may always be solved by trial-and-error. However, a much more effective technique is described below.

Limiting Equations. The quantities $\frac{\Sigma m_i - L}{L}$ and $\frac{\Sigma m_i - V}{V}$ in equation (1) and (2) may be replaced by their equivalent $\frac{V}{L}$ and $\frac{L}{V}$ respectively to become functions of these factors. They are expressed as such along with their first, second and third derivities below.

$$F\left(\frac{V}{L}\right) = \sum_{i=1}^{n} \frac{m_i}{\frac{V}{L} K_i C_L + 1}$$

$$F'\left(\frac{V}{L}\right) = -\sum_{i=1}^{n} \frac{m_i K_i C_L}{\left(\frac{V}{L} K_i C_L + 1\right)^2}$$

$$F''\left(\frac{V}{L}\right) = 2\sum_{i=1}^{n} \frac{m_i K_i^2 C_L^2}{\left(\frac{V}{L} K_i C_L + 1\right)^3}$$

$$F'''\left(\frac{V}{L}\right) = -6\sum_{i=1}^{n} \frac{m_i K_i^3 C_L^3}{\left(\frac{V}{L} K_i C_L + 1\right)^4}$$

$$F\left(\frac{L}{V}\right) = \sum_{i=1}^{n} \frac{m_i K_i}{\left(\frac{L}{V} C_L + K_i\right)}$$

$$F'\left(\frac{L}{V}\right) = -\sum_{i=1}^{n} \frac{m_i K_i C_V}{\left(\frac{L}{V} C_V + K_i\right)^2}$$

$$F''\left(\frac{L}{V}\right) = 2\sum_{i=1}^{n} \frac{m_i K_i C_V^2}{\left(\frac{L}{V} C_V + K_i\right)^3}$$

$$F'''\left(\frac{L}{V}\right) = -6\sum_{i=1}^{n} \frac{m_i K_i C_V^3}{\left(\frac{L}{V} C_V + K_i\right)^4}$$

Only the limiting values of these functions are used as $\frac{V}{L} \to 0$ and $\frac{L}{V} \to 0$

$$\lim_{\frac{V}{L} \to 0} F\left(\frac{V}{L}\right) = \sum_{i=1}^{n} m_i$$

$$\lim_{\frac{V}{L} \to 0} F'\left(\frac{V}{L}\right) = -\sum_{i=1}^{n} m_i K_i C_L$$

$$\lim_{\frac{V}{L} \to 0} F''\left(\frac{V}{L}\right) = 2\sum_{i=1}^{n} m_i K_i^2 C_L^2$$

$$\lim_{\frac{V}{L} \to 0} F'''\left(\frac{V}{L}\right) = -6\sum_{i=1}^{n} m_i K_i^3 C_L^3$$

$$\lim_{\frac{V}{L} \to 0} F\left(\frac{L}{V}\right) = \sum_{i=1}^{n} m_i$$

$$\lim_{\frac{L}{V} \to 0} F'\left(\frac{L}{V}\right) = -\sum_{i=1}^{n} m_i \frac{C_V}{K_i}$$

$$\lim_{\frac{L}{V} \to 0} F''\left(\frac{V}{L}\right) = 2\sum_{i=1}^{n} m_i \frac{C_V^2}{K_i^2}$$

$$\lim_{\frac{L}{V} \to 0} F'''\left(\frac{L}{V}\right) = -6\sum_{i=1}^{n} m_i \frac{C_V^3}{K_i^3}$$

Approximating $F\left(\frac{V}{L}\right)$ with the first four terms of a Maclaurin series gives,

$$L = F(o) + F'(o)\frac{V}{L} + \frac{1}{2!}F''(o)\left(\frac{V}{L}\right)^2 - \frac{1}{3!}F'''(o)\left(\frac{V}{L}\right)^3$$

$$\text{And } L = \frac{\sum_{i=1}^{n} m_i}{\frac{V}{L}+1} = \frac{\sum_{i=1}^{n} m_i}{\frac{V+L}{L}} \text{ with } V + L = \sum_{i=1}^{n} m_i$$

The first three terms give,

$$\frac{L}{V} = \frac{\sum_{i=1}^{n} m_i \frac{C_V}{K_i} - \sum_{i=1}^{n} m_i}{\sum_{i=1}^{n} m_i \frac{C_V^2}{K_i^2} - \sum_{i=1}^{n} m_i} \tag{5}$$

The first four terms give,

$$\frac{L}{V} = \frac{\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i \frac{C_L^2}{K_i^2}\right) \pm \left[\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i \frac{C_L^2}{K_i^2}\right)^2 - 4\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i \frac{C_L^2}{K_i^2}\right)\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i \frac{C_L}{K_i}\right)\right]^{1/2}}{2\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i \frac{C_L^2}{K_i^2}\right)} \tag{6}$$

The term $\dfrac{\sum_{i=1}^{n} m_i}{\frac{V}{L}+1}$ can be approximated very accurately by the polynomial

$$\sum_{i=1}^{n} m_i \left[1 - \frac{V}{L} + \frac{V^2}{L} - \frac{V^3}{L} + \right] \text{ for small values of } \frac{V}{L}$$

This provides limiting equations for small values of $\frac{V}{L}$

The first three terms give,

$$\frac{V}{L} = \frac{\sum_{i=1}^{n} m_i K_i C_L - \sum_{i=1}^{n} m_i}{\sum_{i=1}^{n} m_i K_i^2 C_L^2 - \sum_{i=1}^{n} m_i} \tag{3}$$

The first four terms give,

$$\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i K_i^2 C_L^2\right) \pm \left[\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i K_i^2 C_L^2\right)^2 - 4\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i K_i^2 C_L^2\right)\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i K_i C_L\right)\right]^{1/2}$$

$$\frac{V}{L} = \frac{}{2\left(\sum_{i=1}^{n} m_i - \sum_{i=1}^{n} m_i K_i^2 C_L^2\right)} \tag{4}$$

A similar procedure with F $\left(\frac{L}{V}\right)$ provides limiting equations for small values of $\frac{L}{V}$.

Intermediate Range. The functions F (V) and F (L) are used in the intermediate ranges of vaporization. Their derivitives and the first three terms of their Taylor series expansions are shown below.

$$F'(V) = \left(\frac{\sum_{i=1}^{n} m_i}{V^2}\right)\left(\sum_{i=1}^{n} \frac{m_i K_i C_V}{\left(\frac{\Sigma m_i - V}{V} + K_i\right)^2}\right)$$

$$F''(V) = \left(\frac{-2\sum_{i=1}^{n} m_i}{V^3}\right)\left(\sum_{i=1}^{n} \frac{m_i K_i C_V (K_i - C_V)}{\left(\frac{\Sigma m_i - V}{V} + K_i\right)^3}\right)$$

$$V_A + \Delta V = F(V_A) + F'(V_A)\,\Delta V + \frac{1}{2!}F''(V_A)\,(\Delta V)^2$$

$$F'(L) = \left(\frac{\sum_{i=1}^{n} m_i}{L^2}\right)\left(\sum_{i=1}^{n} \frac{m_i K_i C_L}{\left(\frac{\Sigma m_i - L}{L} K_i C_L + 1\right)^2}\right)$$

$$F''(L) = \left(\frac{-2\sum_{i=1}^{n} m_i}{L^3}\right)\left(\sum_{i=1}^{n} \frac{m_i K_i C_L (1 - K_i C_L)}{\left(\frac{\Sigma m_i - L}{L} K_i C_L + 1\right)^3}\right)$$

$$L_A + \Delta L = F(L_A) + F'(L_A)\,\Delta L + \frac{1}{2!}F''(L_A)\,(\Delta L)^2$$

These have the solutions,

$$\Delta V = \frac{-(F'(V_A) - 1) \pm [(F'(V_A) - 1)^2 - 2(F(V_A) - V_A)\,F''(V_A)]^{1/2}}{F''(V_A)} \tag{7}$$

$$\Delta L = \frac{-(F'(L_A) - 1) \pm [(F'(L_A) - 1)^2 - 2(F(L_A) - L_A)\,F''(L_A)]^{1/2}}{F''(L_A)} \tag{8}$$

Effective Ranges. The point of application and effective range of each equation over which accurate results are obtained are listed below.

Equation	Point Applied	Effective Range
(3)	$\left(\frac{V}{L}\right)_A = 0$	$0 \leqslant \frac{V}{L} \leqslant 0.01$
(4)	$\left(\frac{V}{L}\right)_A = 0$	$0 \leqslant \frac{V}{L} \leqslant 0.02$
(7)	$\frac{\sum_{i=1}^{n} m_i - V_A}{V_A} = 10$	$0.02 \leqslant \frac{V}{L} \leqslant 0.20$

(7) $\dfrac{\sum_{i=1}^{n} m_i - V_A}{V_A} = 1$ $\qquad 0.20 \leqslant \dfrac{V}{L} \leqslant 0.75$

(8) $\dfrac{\sum_{i=1}^{n} m_i - L_A}{L_A} = 1$ $\qquad 0.20 \leqslant \dfrac{L}{V} \leqslant 0.75$

(8) $\dfrac{\sum_{i=1}^{n} m_i - L_A}{L_A} = 10$ $\qquad 0.02 \leqslant \dfrac{L}{V} \leqslant 0.20$

(5) $\left(\dfrac{L}{V}\right)_A = 0$ $\qquad 0 \leqslant \dfrac{L}{V} \leqslant 0.02$

(6) $\left(\dfrac{L}{V}\right)_A = 0$ $\qquad 0 \leqslant \dfrac{L}{V} \leqslant 0.01$

Application—Example No. 1: we have a hydrocarbon mixture for which $S_i \to 1$ for all i. Therefore C_L and C_V are unity. The feed composition, equilibrium K values and factors for application in Equations (3) and (4) are shown below.

Comp.	m (Mole)	K	mK	mK²	mK³
C_2	100	12	1200	14,400	173,000
C_3	150	2	300	600	1,200
C_4	200	0.9	180	162	146
C_5	300	0.2	60	12	2
C_6	250	0.1	25	.....	.....
C_7	400	0.04	16	.....	.....
C_8	200	0.01	2	.....	.....
	1600	.....	1783	15,177	174,450

Equation (3) is applied first.

$$\frac{V}{L} = \frac{1783 - 1600}{15{,}177 - 1600} = 0.0135, \text{ from which } V = \frac{(1600)\,(0.0135)}{1.0135} = 21.3 \text{ Mole.}$$

Since $0.0135 > 0.01$, Equation (4) is applied.

$$\frac{V}{L} = \frac{(1600 - 15{,}177) \pm [(1600 - 15{,}177)^2 - 4\,(1600 - 174{,}450)\,(1600 - 1783)]^{1/2}}{(2)\,(1600 - 174{,}450)}$$

$$\frac{V}{L} = 0.0616,\ 0.0169$$

The extraneous solution most distant from the assumed point is always ignored. It results from the partial series approximation of $f\left(\frac{V}{L}\right)$.

V corresponding to $\frac{V}{L} = 0.0169 = 26.6$ Moles. This result is about 4% high.

This example illustrates the recommended procedure. Equation (3) or (5) is applied first. Then as in this example if the solution is indicated by Equation (3) or (5) to be within the region $0.01 < \frac{V}{L} < 0.02$ or $0.01 < \frac{L}{V} < 0.02$, Equation (4) or (6) is further applied to more accurately establish the solution.

Example No. 2: A second example[1] shown below considers a hydrocarbon mixture for which $C_L = C_V = 1$.

Comp.	m Moles	K	mK	mK²	$\frac{mK}{10+K}$	$\frac{mK}{(10+K)^2}$	$\frac{mK(K-1)}{(10+K)^3}$
C_2	0.0079	12.3	0.0972	1.195	0.00436	0.000195	0.0000987
C_3	0.1321	3.5	0.4630	1.620	0.03430	0.002540	0.0004700
iC_4	0.0849	1.65	0.1400	0.231	0.01200	0.001030	0.0000575
nC_4	0.2690	1.20	0.3230	0.388	0.02890	0.002580	0.0000460
iC_5	0.0589	0.50	0.0294	0.0147	0.00280	0.000266	−0.0000127
nC_5	0.1321	0.39	0.0516	0.0201	0.00497	0.000479	−0.0000281
C_6	0.3160	0.049	0.0155	0.0008	0.00154	0.000153	−0.0000145
	1.0009	....	1.1197	3.4696	0.08887	0.007243	0.0006069

Applying Equation (3) gives $\frac{V}{L} = \frac{1.1197 - 1.0009}{3.4696 - 1.0009} = 0.048$

Since the results from equation (3) indicate that vaporization is somewhat above the effective range of the limiting equations, Equation (7) is applied.

It is applied at $\frac{1.0009 - V_A}{V_A} = 10$, $V_A = 0.0909$ Moles.

$$F'(V_A) = \frac{1}{(0.0909)^2}(0.007243) = 0.876$$

$$F''(V_A) = \frac{-2}{(0.0909)^3}(0.0006069) = -1.62$$

$$\Delta V = \frac{-(0.876-1) \pm [(0.876-1)^2 - 2\,(0.08887 - 0.0909)\,(-1.62)]^{1/2}}{-1.62}$$

$$\Delta V = \frac{0.124 \pm 0.0939}{-162} = -0.0186,\ -0.134$$

Disregarding the extraneous solution, -0.134, $V = 0.0909 - 0.0186 = 0.0722$ Moles which is the reported solution of 0.07 within slide rule accuracy.

Example No. 3: The following example illustrates the application of the method to a problem involving two liquid phases. The water phase is considered to contain negligible quantities of the other components. The oil phase is considered to contain 0.04 mole-fraction of water. $S_I = 0.04$. The method is therefore applicable to the problem.

The value of K_I at the solubility limit is used to test the applicable form of the equations. The temperature of the mixture is 200 F and the pressure is 8 psig.

$$K_I = P_I/\pi x_I = \frac{11.53}{22.7\,(0.04)} = 12.7.$$

In applying equation (3), the value of $\frac{l_I}{L}$ as $\frac{V}{L} \to 0$ can be directly observed. In this problem it is $\frac{68.5}{110.3} > 0.04$. This is not so apparent at conditions that apply close to the dew point. Here $f'_I(o) = \frac{m_I}{K_I}$ is used.

$v_I = m_I + f'_I(o)\,\frac{L}{V}$. And $l_I = m_I - v_I$. Then $l_I = -f'_I(o)\,\frac{L}{V}$. In this example $\frac{l_I}{L} = \frac{-f'_I(o)\,\frac{L}{V}}{L} = -\left(\frac{-68.5}{12.7}\right)\left(\frac{1}{110.3}\right) = 0.0536 > 0.04$. By comparing $\frac{l_I}{L}$ from equation (1) to the expression above, it may be observed that for

$K_I > 1$, $\frac{l_I}{L}$ is minimum at $L \to 0$. And for $K_I < 1$, $\frac{l_I}{L}$ is minimum at $V \to 0$. For $K_I = 1$, $\frac{l_I}{L}$ is constant over the whole range.

The applied values in this example are,

$$C_L = \frac{1 - 0.04}{1 - (0.04)\ (12.7)} = 1.96 \text{ and } C_V = \frac{1}{C_L} = 0.51.$$

The feed composition, equilibrium values and factors for application in equations (3), (6) and (8) are shown below.

Comp.	m (Mole)	K	mKC_L	$mK^2C^2_L$	$\frac{mC_V}{K}$	$\frac{mC^2_V}{K^2}$
H_2O	68.5	12.7	.....	.....	.....	.....
H_2	8.48	700	11,600	156,000	.....	.....
CH_4	0.14	260	71	29,600	.....	.....
C_2H_6	0.20	66	26	3,340	.....	.....
CO	0.70	80	110	17,200	.....	.....
CO_2	0.34	70	47	6,400	.....	.....
Benzene	0.20	0.9	0.4	0.6	0.10	0.05
Toluene	0.34	0.4	.....	.....	0.43	0.55
Ethyl-Benzene	23.50	0.2	.....	.....	60.00	153.0
Styrene	8.20	0.15	.....	.....	28.00	95.0
H_2O Free Total	41.8	.....	11,854	212,540	88.53	248.6

$$\frac{V}{L} = \frac{11{,}854 - 32}{212{,}540 - 32} = 0.06$$

$$\frac{L}{V} = \frac{88.53 - 41.8}{248.6 - 41.8} = 0.223$$

This indicates that vaporization of the components exclusive of $i = I$ is in the midrange with the liquid phase exceeding the vapor phase. Equation (8) is applied at the point $\frac{L}{41.8 - L} = 1$, $L_A = 20.9$ Moles.

Comp.	$\frac{m}{KC_L + 1}$	$\frac{mKC_L}{(KC_L + 1)^2}$	$\frac{mKC_L\ (1 - KC_L)}{(KC_L + 1)^2}$
H_2O	.....	.....	.....
H_2	0.0062	0.0062	—0.0062
CH_4	0.0003	0.0003	—0.0003
C_2H_6	0.0015	0.0015	—0.0015
CO	0.0045	0.0045	—0.0045
CO_2	0.0025	0.0025	—0.0025
Benzene	0.072	0.0461	—0.0127
Toluene	0.190	0.0836	0.0101
Ethyl-Benzene	16.90	4.730	2.0620
Styrene	6.33	1.435	0.7840
H_2O Free Total	23.507	6.31	2.840

$$f'(L_A) = \frac{41.8}{(20.9)^2}(6.31) = 0.604$$

$$f''(L_A) = \frac{-2(41.8)}{(20.9)^3}(2.84) = -0.026$$

$$\Delta L = \frac{-(0.604 - 1) \pm [(0.604 - 1)^2 - 2(23.507 - 20.9)(-0.026)]^{1/2}}{-0.026}$$

$\Delta L = 5.68, -36$. And $L = 26.58$ moles, < 1 percent high.

The amount of water condensed is readily calculated from the knowledge that $y_I = P_I/\pi = 0.509$. Then

$V_T = \frac{41.8 - 26.58}{1 - 0.509} = 31.0$ moles, of which steam is $(0.509)(31.0) = 15.75$ moles. The condensed water phase amounts to 52.75 moles.

About the Author

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NOTATION

$C_L = \frac{1 - S_I}{1 - S_I K_I}$, dimensionless factor in flash equations.

$C_V = \frac{1 - S_I K_I}{1 - S_I}$, dimensionless factor in flash equations.

I = relatively soluble condensible component.

K = equilibrium constant y/x.

L = quantity of main condensed phase, mole.

l = quantity of a component in main condensed phase, mole.

m = total amount of a component, mole.

P = vapor pressure of a pure component, consistant units.

S = solubility of a condensible component in the main condensed phase, mole fraction.

V = quantity of vapor, mole, does not include a component which exists in a separate liquid phase.

v = quantity of a component in the vapor phase, mole.

x = quantity of a component in the main condensed phase, mole fraction.

y = quantity of a component in the total vapor phase, mole fraction.

Subscripts

A = applied value.

i = component index, 1, 2, 3, . . ., n, I.

L = considering the liquid phase.

V = considering the vapor phase.

T = total.

OTHER SYMBOLS

$\to$ = approaches

$>$ = greater than

$\geqslant$ = greater than or equal to

$<$ = less than

$\leqslant$ = less than or equal to

Σ_n = sum over components as noted

π = total pressure, consistant units.

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Know Your Asphalts—Part 2

Composition and Physical Properties

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GROUP SEPARATION of asphalt is practically always physical and carried out on the pure bitumen previously freed of any foreign matter. Three so-called groups or components are separated. They are not chemical entities but consist of empirically separted material of probably hundreds of hydrocarbon mixtures. These separation methods will give consistent, comparable results when using the same solvents and procedure.

Commonly Used Separation Method. Asphalts are separated into three groups as follows:

Asphaltenes: The asphalt is dissolved in benzene and precipitated with low boiling naphtha. Asphaltenes are then separated by centrifugation and the filterate contains the resins and oils.

Resins: The naphtha filtrate is treated with an absorbent and the absorbent is filtered from the naphtha solution. This solution contains the oils which are recovered by distillation of the solvent. This is extracted with chloroform to remove the oils.

The asphaltenes are dark brown to black friable, nonmelting hard materials, soluble in polar solvents (e.g., chloroform, carbon disulfide, etc.) but insoluble in petroleum fractions, e.g., kerosine. Their molecular weights vary from 1200 to 140,000 depending on the method used. They contribute hardness, plasticity, low temperature brittleness, as well as the black color to asphalts.

The resins are light to dark brown semi-solid materials of a highly adhesive nature; good cold ductility, low melting point and brittle at very low temperatures. They may exhibit high or low liquid viscosities depending upon their hydrocarbon make-up. They are the main cohesive agents, tieing the insoluble, yet plasticity yielding asphaltenes together with the oils.

The oils are quite similar to the heavy lubricating oils. They may show high or very low viscosity indices as well as low or high viscosities. At certain temperatures, the oils as dispersion medium are more effective and important than just as diluents. The oil content affects the hardness or softness of asphalts.

Asphalt composition in general varies in relation to the origin of the asphalt with the asphaltenes showing the more distinct differentiation.

Origin	Percentage Asphaltenes
Ebano, Panuco (Heavy Mexican), Mississippi (Heavy Crude)	27-31
Lagunillas (Venezuelan)	18
California from Heavy Crude Kuwait (vacuum reduced)	7-11

Average values of the general run of paving asphalts of 60 penetration, similar in penetration to the above are:

Asphaltenes	28 percent
Resins	40 percent
Oils	32 percent

Physical Properties and Rheology: Pure asphalts or bitumens are a colloidal dispersion of submicroscopic asphaltene particles (dispersed phase) in an oil medium (dispersion medium). The particles are peptized or stabilized to various degrees by the resins, the protective colloids, or peptizers.

The resins are also considered polar and are adsorbed on the surface of the asphaltenes. The adsorbed resins plus the asphaltenes are termed miscelles.

The type of asphalt and its physical behavior depends on:

1. Fineness or coarseness of the asphaltene particle as well as the asphaltene content of the asphalt. This is influenced by how well the asphaltenes are peptized with the excess of resin. High resin content and low asphaltenes with resins and aromatic oils results in a sol-type asphalt. Gel-types result from low resin content, high asphaltenes and paraffinic oils forming "coarse" colloidal dispersions.
2. Resin content; nature of the resins, e.g., viscosity, etc. The highly dispersed type, with high resin content, will be found to be fairly susceptible to temperature change, shows a low viscosity when molten, medium to low melting point relative to hardness and becoming brittle at higher temperatures than do the gel type of asphalt.
3. Oil content and nature of the oily medium whether paraffinic, naphthenic or naphtheno-aromatic.

Other properties than those shown in Table 1 must be considered from a rheological standpoint. Such properties are: cold flow, viscosity range at various temperatures, hardness, brittleness, elasticity, thixotropy, dilatancy, stiffness modulus, age hardening, plasticity and others.

TABLE 1
Physical Constants of Three Important Types of Asphalts

	Sol	Sol-Gel	Gel
Colloid Type			
Rheological Type	Newtonian	Visco-Elastic	Elastic
Hardness (penetration);			
At 32 F	57	16	40
At 77 F	50	55	53
At 115 F	320	148	120
Temperature Susceptibility	Very High	Normal	Very Low
Ductility at 77 F	Very High	High	Very Low
Penetration Index (Shell)	—1.2	0.2	2.3
Melting Point (R&B), F	122	131	150
Degree of Complex Flow, c, (Traxler)	1.0	0.8	0.5

Many of these properties are related or may be phases or forms of some other, more easily measurable, fundamental property. Many of the useful desirable properties of an asphalt are those of the solid material at ordinary temperatures down to and below freezing.

Any group analysis of asphalt is empirical with percentages varying with the method used.

In addition to the three groups determined by separator methods, there may be small amounts of organic matter insoluble in carbon disulfide called "carboids," and insoluble in carbon tetrachloride termed "carbenes." These low hydrogen hydrocarbons are often derived from cracking reactions or overheating at high temperatures, e.g., 600 F.

Recent investigations indicate there may not be a definite hard asphaltene nucleus according to the earlier concept of Nellensteyn. The asphaltene particle may be a hard high-carbon low-hydrogen content hydrocarbon which adsorbs high molecular weight according to polarity, to varying degrees.

Part 3 will appear in an early issue.

How Metals Behave at Low Temperatures

Here's the reason some of the properties of metals are improved at low temperatures while others, such as ductility, may be impaired.

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ALL METALLIC materials increase in strength, hardness, fatigue limit, and elastic modulus at low temperatures. The ductility, on the other hand, may be adversely affected by low temperatures. This is usually the case in ferrous materials, as these become notch sensitive at sub-atmospheric temperatures.

In recent years a great deal of attention has been given to low-temperature properties of metals and alloys. The significance of the study of low-temperature properties, however, extends far beyond the direct application of materials at such temperatures. Good low-temperature behavior is important inasmuch as a material that performs satisfactorily at low temperatures, from a ductility point of view, is likely to perform well under severe conditions at higher temperatures.

The Transition Behavior. It is well known that certain materials, including most steels, undergo a change from ductile to brittle fracture over a definite temperature range. This phenomenon is not observed in materials with face-centered cubic crystal structure, such as austenitic steels. (Other metals having a face-centered cubic structure include copper, aluminum, silver, lead, nickel, gold, platinum.) The transition from ductile to brittle behavior can also be produced at a constant temperature simply by varying the rate of application of the load or by changing the stress conditions.[1]

It cannot be over-emphasized that the transition temperature has a meaning only if the testing conditions are fully known. Figure 1[2] gives an example of the effect of varying notch conditions and different rates of load application upon the transition behavior of a steel.

Some interesting work done in recent years was concerned with the

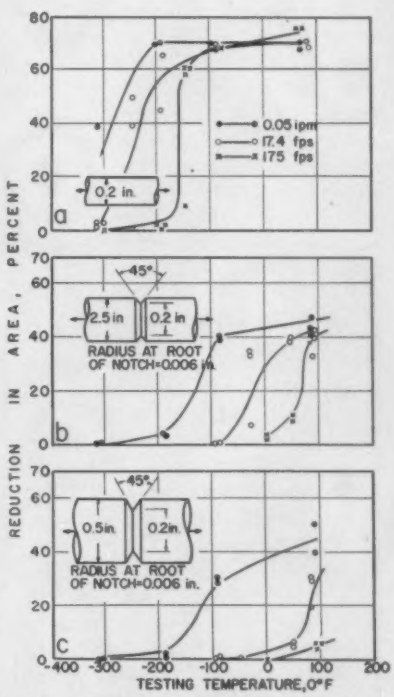

FIGURE 1—Varying the rate of load application produces a marked effect on the reduction in area.

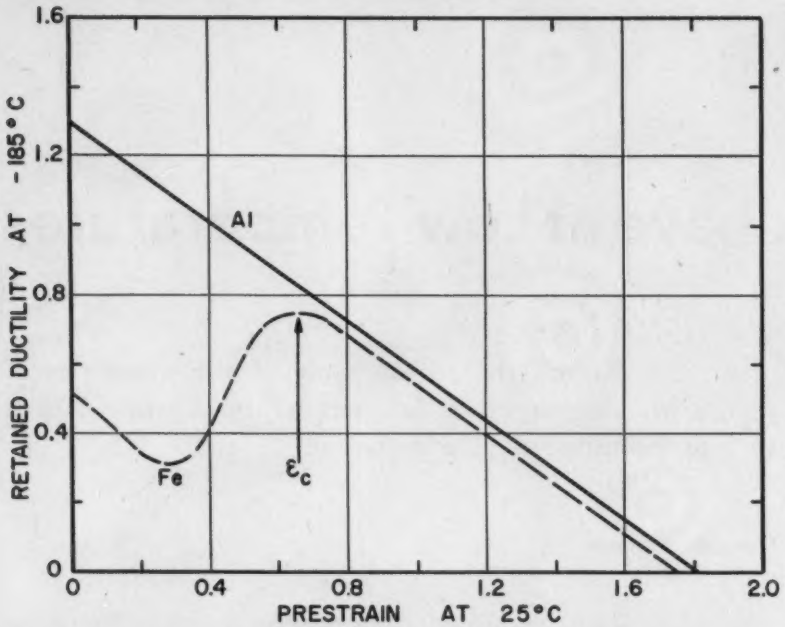

FIGURE 2—Iron embrittlement compared to aluminum shows that prestraining iron 0.6 would give high strain at low temperatures.[5]

effect of varying temperature upon the ductility of metallic single crystals of high purity.[3] In these cases, virtually no change in ductility was observed in face-centered cubic materials. Body centered cubic and close-packed hexagonal materials, on the other hand, revealed an extremely narrow temperature zone of transition from ductile to brittle failure. (Body-centered cubic structures are associated with most steels, molybdenum, chromium, vanadian, tungsten. Close-packed hexagonal structures include zinc, cadmium, magnesium, beryllium, titanium, and zirconium.)

About the Author

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One may conclude, therefore, that the existence of a transition behavior cannot be attributed to inadequate manufacturing processes or faulty material but must be associated with the nature of the material itself. Yet, the actual temperature range, in which the transition takes place is strongly affected by the purity and cleanliness of the material tested.

The concept of ductility involves the idea of testing materials to fracture. Indeed, ductility may be defined as the amount of permanent deformation prior to fracture. It would not be amiss, therefore, to discuss briefly the nature of fracture itself.

Basically there are two types of fracture: (1) ductile fracture, and (2) brittle fracture. The latter may take place either through the grains (transcrystalline fracture) or along the grain boundaries (intercrystalline fracture).

If, for example, the carbon content of a high-purity iron alloy is reduced, the material tends to become more and more ductile. If, however, the carbon content drops below about 0.01 percent, the trend is reversed. This is due to the formation of iron-oxide films between the grains at high temperatures. The grain boundaries, therefore, constitute a brittle network which fails easily through intercrystalline rupture when the material is tested. Hot or cold working may break up this brittle network, but precipitation of an oxide in the grain boundaries may occur even at comparatively low temperatures.

If deoxidizers, such as titanium or aluminum, are added to the iron, the ductility rises again. It is assumed generally that the limit for good ductility is near an oxygen content of about 0.003 percent.[4]

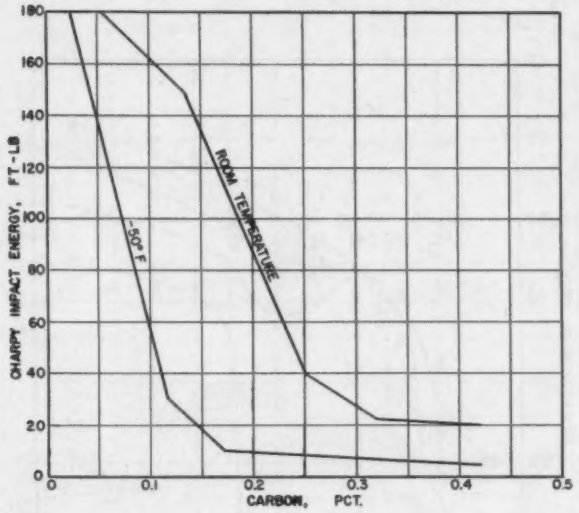
The possibility of brittle or weak grain boundary deposits is of extreme importance in all cases of brittle fracture. Nevertheless, none of the present concepts for fracture of solids provides a satisfactory interpretation of the sudden transition from ductile to brittle failure.

The transition phenomenon, under certain conditions, may be partly cured. Aluminum, for example, has no transition behavior. When prestrained at room temperature, it attains a correspondingly smaller amount of strain when tested subsequently at liquid-nitrogen temperature, Figure 2.[3] On the other hand, iron tested under similar conditions will not behave this way.

Indeed, it would appear from Figure 3 that a pre-strain of approximately 0.6 would be advantageous for obtaining a high degree of strain at low temperatures. This suggests that part of the loss in ductility, which is suffered by certain materials that undergo a sudden transition from brittle to ductile fracture, can be cured by pre-straining at a temperature above the transition zone.[5]

Composition and Microstructure. In general, carbon exerts an unfavorable influence upon the transition temperature of iron.[6] With addition of carbon, the transition temperature increases, so that the ductility and toughness at low temperature are impaired, Figure 3.[2] The effect of nitrogen has not been studied too thoroughly. Yet, it is known that open-hearth steel is generally superior to Bessemer steel for low-temperature applications.[7] This is probably due to the higher nitrogen content in Bessemer steel. As pointed out earlier, oxygen is particularly bad for the low-temperature ductility of iron.

Aluminum, which binds oxygen as well as nitrogen, generally improves the low-temperature ductility because of its removal of these obnoxious elements. An aluminum-killed steel, in general, is superior to any other kind of steel, including silicon-killed steels.



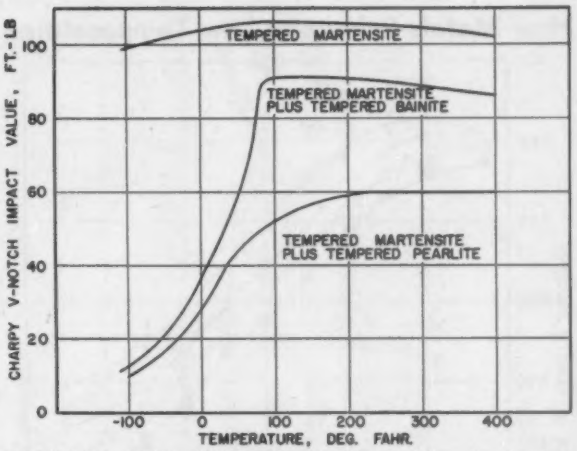


FIGURE 3—(left) Additional carbon in steel impairs the ductility and toughness at low temperatures.[5]

FIGURE 4—(above) A test of 8735 steel at 125,000 psi tensile strength indicates poor low temperature properties of tempered pearlite.[6]

Manganese exerts a favorable influence upon low-temperature ductility and should be contained in sufficient quantities in any steel intended for low temperature service.[6] Steels used at moderately low temperatures should have a ratio of manganese to carbon greater than four.[7] Nickel, similarly to manganese, improves low-temperature properties.[2] In a ferritic nickel steel containing 0.34 percent carbon and 3.3 percent nickel, virtually no change in ductility was observed when the material was cooled from room temperature to —130 F. At —423 F, however, this steel had practically no ductility.[1] Certain ferritic nickel-chromium-molybdenum steels possess excellent properties at low temperatures, as shown in Table 1.

For low-temperature performance steels of fine grain size generally are preferable to those having a coarse grain.[2] As far as the microstructure is concerned, tempered martensite is most desirable. As a general rule, structures which contain carbides dispersed in an extremely fine form are advantageous for low temperature service. When materials are annealed or normalized, the carbide particles grow and may eventually take up lamellar shape (pearlite), resulting in poorer low-temperature properties, Figure 4.[6]

In a 4340 steel, for example, which was heat treated to the same hardness by (a) quenching and tempering and (b) normalizing and tempering, the impact transition temperature of the latter was 350 degrees F higher than that of the former. Slack quenching produces transition temperatures intermediate to those obtained with tempered martensite and pearlite structures. If the formation of pearlite is unavoidable, spheroidization treatments will improve low-temperature properties. Coarse pearlite and coarse bainite structures are associated with unfavorable low-temperature ductility. This is of particular importance in the case of welding, which may cause the formation of coarse structures in the heat-affected zone.

Inasmuch as tempered structures offer greatest advantages to low-temperature service, the question as to the best tempering temperatures arises. Maximum cold toughness can be obtained with tempering temperatures near 1250 F.[7] Of course, the tempering temperature must be selected according to strength requirements.

The tensile strength of steels decreases as higher tempering temperatures are used, Figure 5.[8] While this figure indicates a relatively simple relationship between the strength and the tempering temperature, the ductility varies in a rather anomalous fashion, Figure 6. At low testing temperatures, a minimum in ductility occurs near the tempering temperature of 600 F.

TABLE 1

Mechanical Properties at Low Temperatures of a Forged Nickel-Molybdenum-Chromium Steel*

Composition: 0.33%C, 0.64%Mn, 2.54%Ni, 0.67%Cr, 0.64%Mo, 0.16%Si, 0.012%S, 0.038%P.

Treatment: Oil quenched from 1560 F., tempered at 1185 F.

Testing Temperature °F.	Yield Strength psi	Tensile Strength psi	Elongation %	Reduction in Area %
70	137,000	152,000	14	65
— 6	141,000	154,000	16	64
— 76	143,000	163,000	14	63
— 89	145,000	163,000	16	62
—141	149,000	170,000	16	61
—292	183,000	201,000	17	63

* From Teed, Ref. (1).

Since tempered martensite is such a desirable microstructure, the material should contain as much martensite as possible after quenching. As a result, steels of high hardenability are certainly the most effective for low-temperature service. Alloy addition, which promotes hardenability, may retain austenite. Such austenite may become harmful to low-temperature ductility.

Among the mechanical variables that affect low-temperature behavior are, of course, notches. In general, the sharper the notch, the higher the transition temperature. Another variable is that of cold work prior to testing. If the cold work is undertaken at temperatures below the transition temperature, it has an adverse effect upon the transition temperature.[9]

The phenomenon of temper embrittlement strongly affects the low-temperature ductility of materials. This effect is noticeable primarily during rapid deformation, such as found in impact.[10] Temper embrittlement is probably due to the precipitation of some carbides in the temperature range between 900 and 1100 F.[11] Thus, slow cooling through this range or holding in this range should be avoided. The effect of temper embrittlement upon the transition temperature is illustrated in Figure 7.

If a material is supposed to retain a certain degree of ductility at low temperatures, the type and the distribution of stresses as well as the rate of strain must be taken into considera-

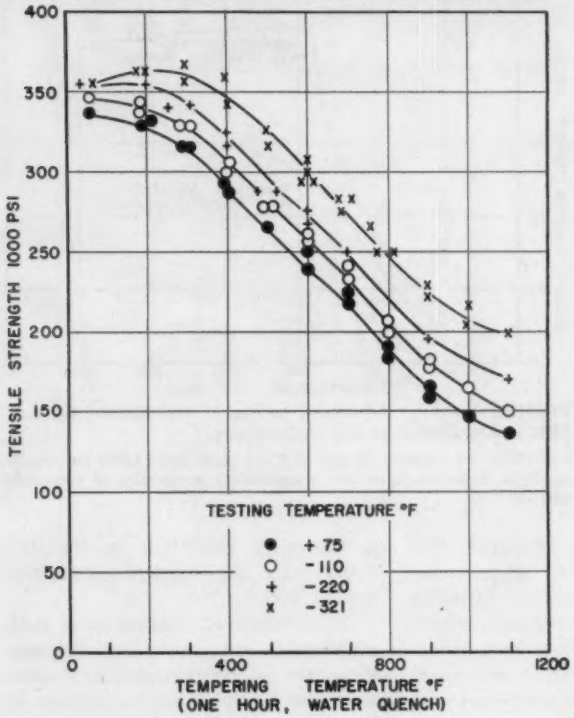


FIGURE 5—(left) Higher tempering temperatures decrease the tensile strength of steels.[8]

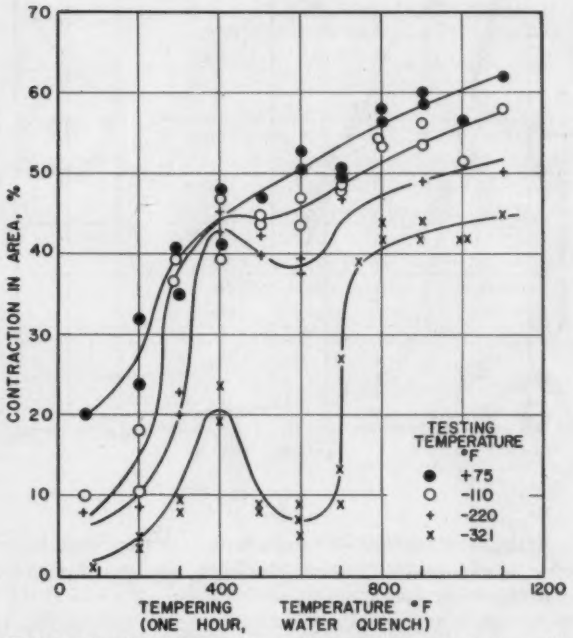


FIGURE 6—(above) A minimum in ductility occurs near a tempering temperature of 600 F.[8]

tion. For severe service conditions the transition temperature, determined by Charpy test, should be as low as possible. If high notch-impact properties are required at temperatures down to —80 F, plain carbon steels may do a satisfactory job, provided the carbon content does not exceed 0.15 percent and the manganese: carbon ratio is greater than four. Such steels should be aluminum-deoxidized, have fine grain size, and should not have been subjected to cold work. Alloy steels preferably should be quenched and tempered near 1250 F. For very low temperature, i.e., below —200 F, steels of the 2300, 4100, 4300, 8600, and 8700 series are recommended.

Mechanical Properties. The elastic modulus of metallic materials increases as the temperature is lowered. The elastic modulus of steels increases by about 4200 psi per degree Fahrenheit drop of temperature between room temperature and —60 F.[1]

The yield and tensile strengths rise with lower temperatures. This increase is very pronounced in body-centered cubic materials, Table 2,[1] less so in close-packed hexagonal materials. It is quite small, yet noticeable, in face-centered cubic metals. The increase in strength associated with low temperatures is independent of the carbon content of the steel. Strain hardening also becomes more pronounced at lower temperatures.[3]

Again, in face-centered cubic materials this effect is mild while body-centered cubic metals, such as iron, suffer a greater increase in strain-hardening coefficient at lower temperatures. A high strain-hardening coefficient is often associated with low reduction in area. This is because high strain hardening causes resistance to localized deformation, such as obtained during necking. Thus, it induces a more uniform distribution of the cross-sectional reduction over the entire specimen.

The strain rate has a definite effect upon the strength. Certain formulas have been proposed which, somewhat like the equation of state for gases, would correlate for solids the variables of strain rate, yield stress, and temperature. These equations are all empirical in nature. One of these[9] is

$$\frac{\dot{\varepsilon}}{\dot{\varepsilon}_o} = Ae^{-\frac{B}{T}}$$

where $\dot{\varepsilon}$ is the strain rate, e the base of the natural logarithm, $\dot{\varepsilon}_o$, A, and B constants dependent on the material and the flow stress.

Just like the yield and tensile strengths, the fatigue limit of most materials rises at lower temperatures. It is believed that the increase in yield strength causes a more difficult initiation of cracks on the specimen surface,

TABLE 2

Mechanical Properties at Low Temperatures of Armco Iron*

Composition: 0.035%C, 0.02%Mn, Si trace, 0.016%S, 0.003%P.

Testing Temperature °F.	Yield Strength psi	Tensile Strength psi	Elongation %	Reduction in Area %
70	.....	46,000	28	73
— 4	33,000	54,000	42	75
— 58	42,000	59,000	43	74
— 94	43,000	62,000	38	72
—148	57,000	67,000	27	70
—184	67,000	77,000	17	68
—292	.....	112,000	0	0

* From Teed, Ref. (1).

TABLE 3

Mechanical Properties at Low Temperatures of an Austenitic Stainless Steel.*

Composition: 0.11%C, 0.49%Mn, 10.05%Ni, 18.3%Cr, 0.25%Si, 0.019%S, 0.005%P.

Treatment: Water quenched from 2012 F.

Testing Temperature °F.	Yield Strength psi	Tensile Strength psi	Elongation %	Reduction in Area %
70	37,000	92,000	54	74
— 4	43,000	114,000	63	73
— 76	50,000	136,000	61	74
—141	54,000	154,000	46	70
—177	73,000	178,000	49	63
—292	74,000	222,000	46	55

* From Teed, Ref. (1).

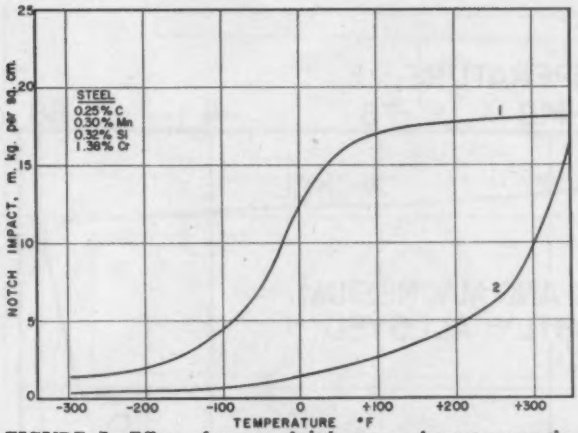


FIGURE 7—Effect of temper brittleness on impact properties of a steel (0.25%C, 1.38%Cr) tempered to a hardness of 241 Brinell. Curve 1: Tempered 1 hour at 1200 F. followed by a water quench. Curve 2: Same treatment, followed by reheating to 975 F for 24 hours, resulting in severe temper embrittlement.[11]

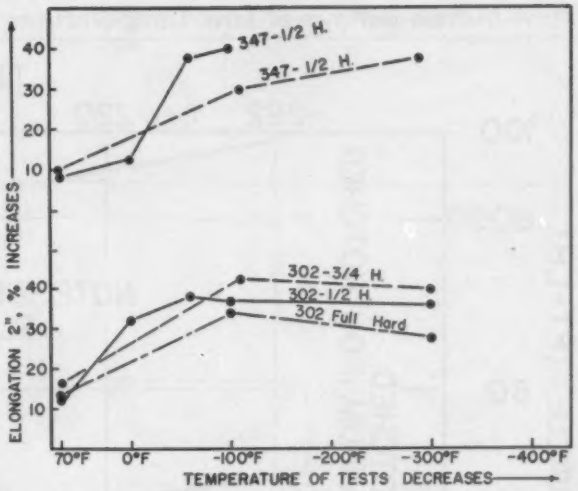


FIGURE 8—In cold worked, austenitic, stainless steel the ductility may increase as deformation temperature is lowered.[13]

yet at low temperatures the cracks will propagate more readily.[12]

Stainless Steels. Among the most important materials to be used at very low temperatures are the austenitic stainless steels. These steels are actually not stable and particularly under deformation at low temperatures tend to transform into martensite. With the formation of martensite, the face-centered cubic austenitic structure loses much of its low-temperature ductility. Nevertheless, the general properties of austenitic stainless steels are excellent, as shown by the example given in Table 3.

In cold-rolled austenitic stainless steel the ductility measured in percent elongation may even increase as the temperature of deformation is lowered, Figure 8.

In the use of austenitic stainless steel care must be taken to avoid the formation of "sigma" phase. This extremely brittle phase is an iron-chromium compound which is associated with low impact properties both at ordinary and low temperatures. The sigma phase forms at approximately 1350 to 1650 F. Its harmful effect is about equally pronounced at low and high temperatures, Table 4. Another possible hazard in the use of stainless steels is so-called sensitization. This is the precipitation of an iron-chromium carbide in the grain boundaries of austenitic steel. It, too, may have ill effects upon the ductility at room as well as at low temperatures.

The strength of stainless steels increases greatly as the temperature is lowered, especially in the annealed state.[13] This increase is highly composition dependent and may be due to a phase change under deformation at low temperatures.

TABLE 4

Effect of Sigma Phase on the Notch Toughness at Room and Low Temperatures of Different Austenitic Stainless Steels*

Chemical Composition					Condition	Charpy (Keyhole) Impact at		
C	Cr	Ni	Mo	Cb		Room Temperature	—105 F.	—320 F.
%	%	%	%	%		Ft.-Lb.	Ft.-Lb.	Ft.-Lb.
0.020	17.71	11.17	2.44	....	Annealed.....	65	63	65
					Sigmatised.....	29	21	25
.023	17.80	13.10	2.76	....	Annealed.....	69	61	61
					Sigmatised.....	43	31	22
.021	17.30	14.10	2.94	....	Annealed.....	69	63	60
					Sigmatised.....	47	37	29
.022	18.12	12.68	2.12	0.48	Annealed.....	54	50	53
					Sigmatised.....	12	10	8
.022	18.62	14.02	2.15	.32	Annealed.....	70	61	61
					Sigmatised.....	23	17	12
.020	17.01	11.0	....	.36	Annealed.....	63	72	65
					Sigmatised.....	50	52	43

* From Krivobok, Ref. (13).

Non-Ferrous Metals. Among the non-ferrous metals that have been used at low temperatures is aluminum and its alloys. In relatively pure aluminum, properties remain virtually unaffected by low temperatures, Table 5. Aluminum alloys, on the other hand, may suffer a decrease in ductility as the temperature is lowered, Table 6.

Impact properties over a large temperature range of different unalloyed metals are shown in Figure 9. The relative independence of the impact behavior of temperature of face-centered cubic materials, i.e., copper, aluminum, nickel, and lead, is very much in evidence.

TABLE 5

Mechanical Properties at Low Temperatures of Wrought Aluminum*

Composition: 0.07%Fe, 0.054%Si.
Treatment: Rolled and annealed.

Testing Temperature °F.	Yield Strength psi	Tensile Strength psi	Elongation %	Reduction in Area %
70	4,500	9,800	36	90
14	3,800	11,400	36	90
— 40	4,000	11,600	40	92
—112	4,250	11,900	38	92
—184	3,600	14,100	40	90
—292	4,500	21,000	44	87

* From Teed, Ref. (1).

TABLE 6

Mechanical Properties at Low Temperatures of a Wrought Aluminum Alloy*

Composition: 3.72%Cu, 0.62%Mg, 0.59%Mn, 0.46%Si, 0.43%Fe.

Treatment: Water quenched from 940° F., and aged.

Testing Temperature °F.	Yield Strength psi	Tensile Strength psi	Elongation %	Reduction in Area %
70	41,500	59,500	22	30
—105	43,000	61,000	21	23

* From Teed, Ref. (1).

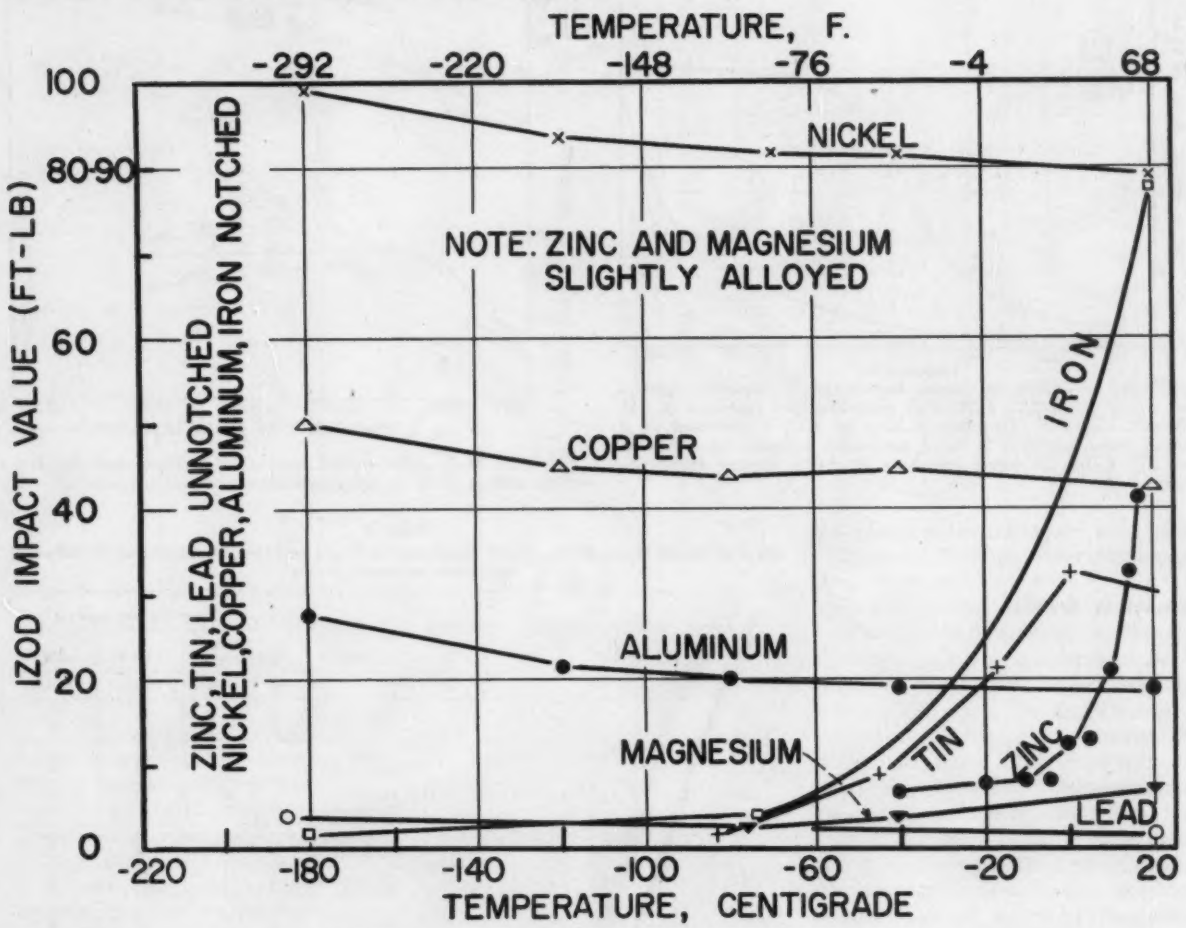


FIGURE 9—Impact behavior of face-centered, cubic materials (i.e. copper, aluminum, nickel, lead) is unaffected by a change in testing temperature.[7]

Design Factors. As the notch sensivity increases, sharp fillets and reentrant angles must be avoided at all cost. Because of higher hardness at low temperatures greater resistance to deformation at the root of the notch ensues. Thus, all notches, including those produced by cracks during quenching, become harmful.[12] Residual stresses are, of course, undesirable and should be relieved.

Attention should be given to the stress-relieving temperature which must not lie in the temper-embrittling range. The preheating of welds is generally desirable as a more even cooling can be produced and unnecessary residual stresses suppressed. It is difficult to avoid formation of pearlite and coarse bainite at the center of such sections, unless the hardenability is exceptionally good.

As a result, high-strength materials in thin sections are generally preferable to heavy sections of low-strength materials. Surface treatments, such as flame or induction hardening, carburizing or nitriding, produce hard surfaces which are usually notch sensitive even at room temperature. Their behavior at low temperature is correspondingly unsatisfactory. Welds may increase the notch sensitivity by introducing impurities.

For example, hydrogen may be picked up from electrode coatings and nitrogen from the atmosphere. Hydrogen can be expelled by heating of the part for a certain length of time. When heating steel, which has absorbed a certain amount of nitrogen, at temperatures below 800 F, nitrides form which are detrimental to the ductility of the material. It is claimed that a manganese-carbon ratio of greater than seven minimizes the precipitation of nitrides.[7]

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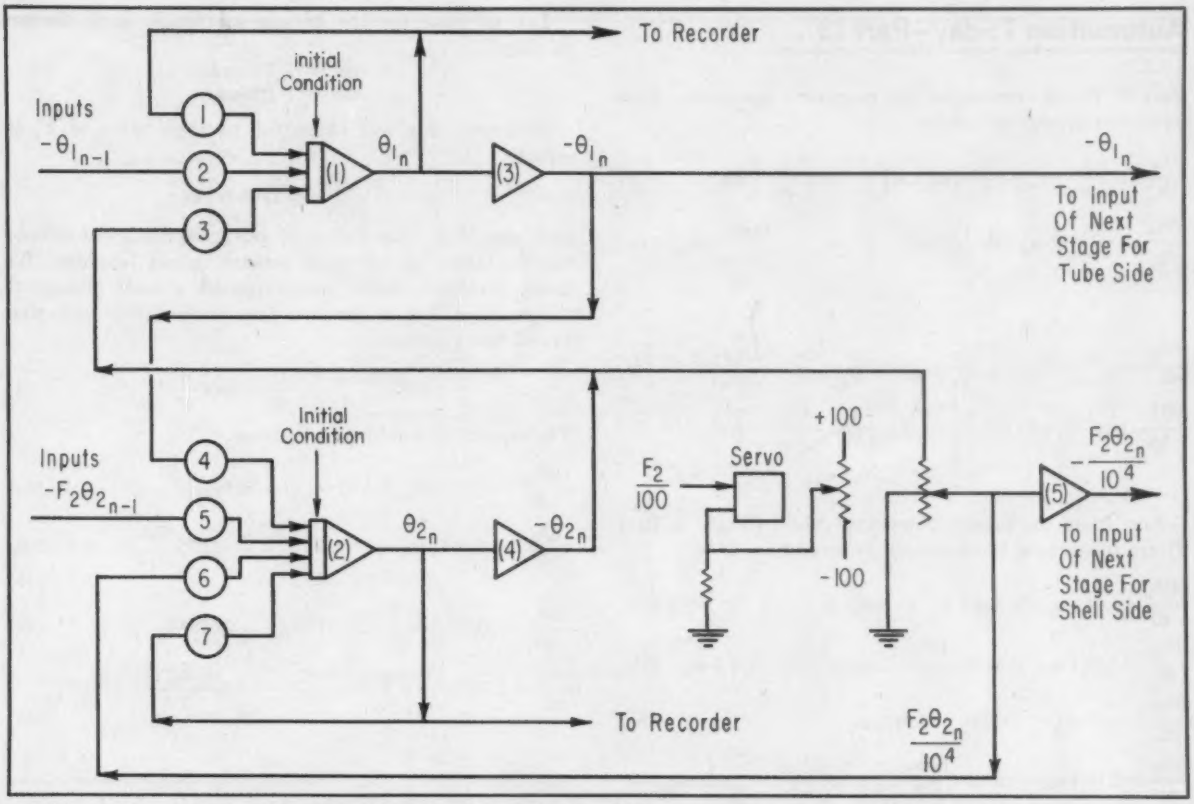

FIGURE 71—Here is an example of the computer setup required to solve equations (4c) and (4d) involving sections c and c'. The settings for the numbered potentiometers are shown in Table 1. A similar setup may be made for each pair of equations.

Automation Today

Part 13

This example problem uses a shell and tube exchanger to show how analog computers can simulate refining processes.

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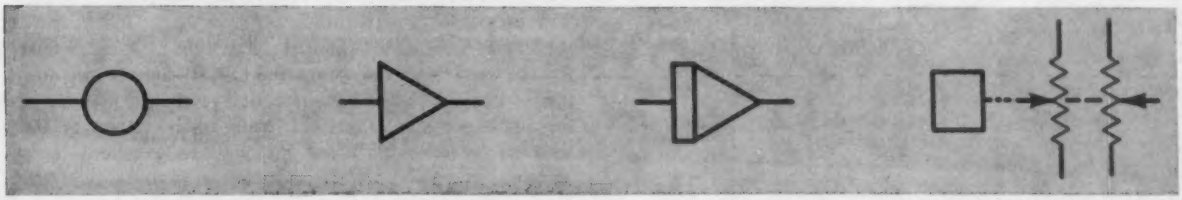
THE PLACE of the analog computer in process simulation and the function of its component parts have been discussed in previous parts of this series. Now a numerical problem will be presented using a tube and shell exchanger as an example. This will be the same simplified version of the exchanger described in Part 9 (PETROLEUM REFINER, March, 1957, page 230). The reader is referred to this previous part for a derivation of the equations to be used here.

The response of the heat exchanger with its controller may be completely described with a family of eleven simultaneously differential equations. Ten of these equations are represented by Equations (4a) through (4j) of

These symbols were used to construct the electrical diagrams



Potentiometer **Sign Changer** **Integrator** **Servo Multiplier**

Automation Today—Part 13 . . .

Part 9. When rearranged for computer operation, these equations appear as follows:

$$\frac{d\Theta_{2a'}}{dt} = \frac{hA_a}{V_{a'}\rho c_p}(\Theta_{2a}) + \frac{F_1}{V_{a'}}(\Theta_{1_1}) - \left[\frac{F_1}{V_{a'}} + \frac{hA_a}{V_{a'}\rho c_p}\right](\Theta_{1a'}) \quad (1a)$$

$$\frac{d\Theta_{2a}}{dt} = \frac{hA_a}{V_a\rho c_p}(\Theta_{1a'}) + \frac{F_2}{V_a}(\Theta_{2_1}) - \frac{F_2}{V_a}(\Theta_{2a'}) - \frac{hA_a}{V_a\rho c_p}(\Theta_{2a}) \quad (1b)$$

. . . .

. . . .

$$\frac{d\Theta_{2e}}{dt} = \frac{hA_e}{V_e\rho c_p}(\Theta_{1e'}) + \frac{F_2}{V_e}(\Theta_{2d}) - \frac{F_2}{V_e}(\Theta_{2e}) - \frac{hA_e}{V_e\rho c_p}(\Theta_{2e}) \quad (1f)$$

$$\frac{d\Theta_{1b'}}{dt} = \frac{hA_b}{V_{b'}\rho c_p}(\Theta_{2b}) + \frac{F_1}{V_{b'}}(\Theta_{1a'}) - \left[\frac{F_1}{V_{b'}} + \frac{hA_b}{V_{b'}\rho c_p}\right](\Theta_{1b}) \quad (1i)$$

. . . .

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And when the proper numerical values (Table 1, Part 9) are substituted these equations become:

$$\frac{d\Theta_{1a'}}{dt} = 452\ \Theta_{2a} + 6040\ \Theta_{1_1} - 6492\ \Theta_{1a'} \quad (2a)$$

$$\frac{d\Theta_{2a}}{dt} = 216.1\ \Theta_{1a'} + 6450\ \frac{F_2\Theta_{2_1}}{10^4} - 6450\frac{F_2\Theta_{2a}}{10^4} - 216.1\ \Theta_{2a} \quad (2b)$$

$$\frac{d\Theta_{1c'}}{dt} = 452\ \Theta_{2c} + 3020\ \Theta_{1a'} - 3472\ \Theta_{1c'} \quad (2c)$$

$$\frac{d\Theta_{2c}}{dt} = 216.1\ \Theta_{1c'} + 3230\ \frac{F_2\Theta_{2b}}{10^4} - 3230\frac{F_2\Theta_{2c}}{10^4} - 216.1\ \Theta_{2c} \quad (2d)$$

. . . .

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$$\frac{d\Theta_{2e}}{dt} = 216.1\ \Theta_{1e'} + 6450\ \frac{F_2\Theta_{2d}}{10^4} - 6450\frac{F_2\Theta_{2e}}{10^4} - 216.1\ \Theta_{2e} \quad (2f)$$

. . . .

. . . .

$$\frac{d\Theta_{1b'}}{dt} = 452\ \Theta_{2b} + 3020\ \Theta_{1a'} - 3472\ \Theta_{1b'} \quad (2i)$$

. . . .

. . . .

Units of temperature in each case are given as degrees F. per hour. All units are given here initially in hours since this is usually used in heat transfer work.

TABLE 1
Settings for the Potentiometers in Figure 71

No.	Symbols	Possible Value
1	$\frac{F_1}{V_{a'}} + \frac{hA_a}{V_{a'}\rho c_p}$	0.579
2	$F_1/V_{a'}$	0.503
3	$\frac{hA_a}{V_{a'}\rho c_p}$	0.0753
4	$\frac{hA_a}{V_a\rho c_p}$	0.0361
5	$\frac{10^4}{V_a}$	0.538
6	$\frac{10^4}{V_a}$	0.538
7	$\frac{hA_a}{V_a\rho c_p}$	0.0361

Let us now set the proper amplitude scale factors so that

1 volt = 1 F., and
1 volt = 1 ft³/hour.

However, this will cause the average value of F_2 to equal

$$\frac{175{,}000}{62.5} = 2800\ \text{ft}^3/\text{hr}$$

and, therefore, the values of our terms will far exceed the limitation of 100 volts present in our machine. We must, therefore, make some type of a scale change in the problem. Let us choose a time scale change such that (t still being in hours):

$$6000\,t = \tau \quad \text{and} \quad \frac{d}{dt} = 6000\frac{d}{d\tau} \quad (3)$$

The equations would then become

$$\frac{d\Theta_{1a'}}{d\tau} = 0.0753\ \Theta_{2a} + 1.01\ \Theta_{1_1} - 1.08\ \Theta_{1a'} \quad (4a)$$

$$\frac{d\Theta_{2a}}{d\tau} = 0.0361\ \Theta_{1a'} + 1.075\ \frac{F_2\Theta_{2_1}}{10^4} - 1.075\ \frac{F_2\Theta_{2a}}{10^4} - 0.0361\ \Theta_{2a} \quad (4b)$$

$$\frac{d\Theta_{1c'}}{d\tau} = 0.0753\ \Theta_{2c} + 0.503\ \Theta_{1a'} - 0.579\,\Theta_{1c'} \quad (4c)$$

$$\frac{d\Theta_{2c}}{d\tau} = 0.0361\,\Theta_{1c'} + 0.538\frac{F_2\Theta_{2b}}{10^4} - 0.538\frac{F_2\Theta_{2c}}{10^4} - 0.0361\Theta_{2c} \quad (4d)$$

. . . .

. . . .

Notice that a time scale change of $3600\,t = \tau$ is equivalent to considering seconds as the unit of time rather than hours. Thus with computer time normally being given in seconds, our computer scale change of $6000\,t = \tau$ with t originally in hours is really only a slowing down of the problem by a factor of 6000/3600 = 1.667 in real time with the problem factors now being given in terms of seconds. Therefore, we can return to true time by converting our recorder scale so that 10 machine gradations will be equal to 6 real time gradations.

Figure 71 gives the required computer diagram to solve any pair of the above equations, such as Equations (4c) and (4d) involving sections c and c′. The settings for the potentiometers are shown in Table 1. Because of the varied volumes involved, the coefficients for the equations and thus the settings of the potentiometers for sections a, a′, e, and e′ will be somewhat different. However, the form of the equations and thus of the computer setup will be identical. Two integrators are necessary, one to sum the rates of temperature change for the tube or cold side fluid, and one for the shell or hot side fluid.

In addition, a servomultiplier is necessary to handle the multiplication of (F_2) (Θ_2) since both are variables. The output of a servomultiplier is xy/100 (see Part 12); therefore, we can obtain the term $F_2\Theta_2/10^4$ by entering $F_2/100$ into the servo. Since the initial value of this number is 28, it is of the right order of magnitude for use on our computer. Thus the time scale change of 6000 to 1 which we made turns out to be an excellent choice, and no magnitude scale change as such is necessary. Notice that units of flow are still ft³/hour even though computer time is in seconds.

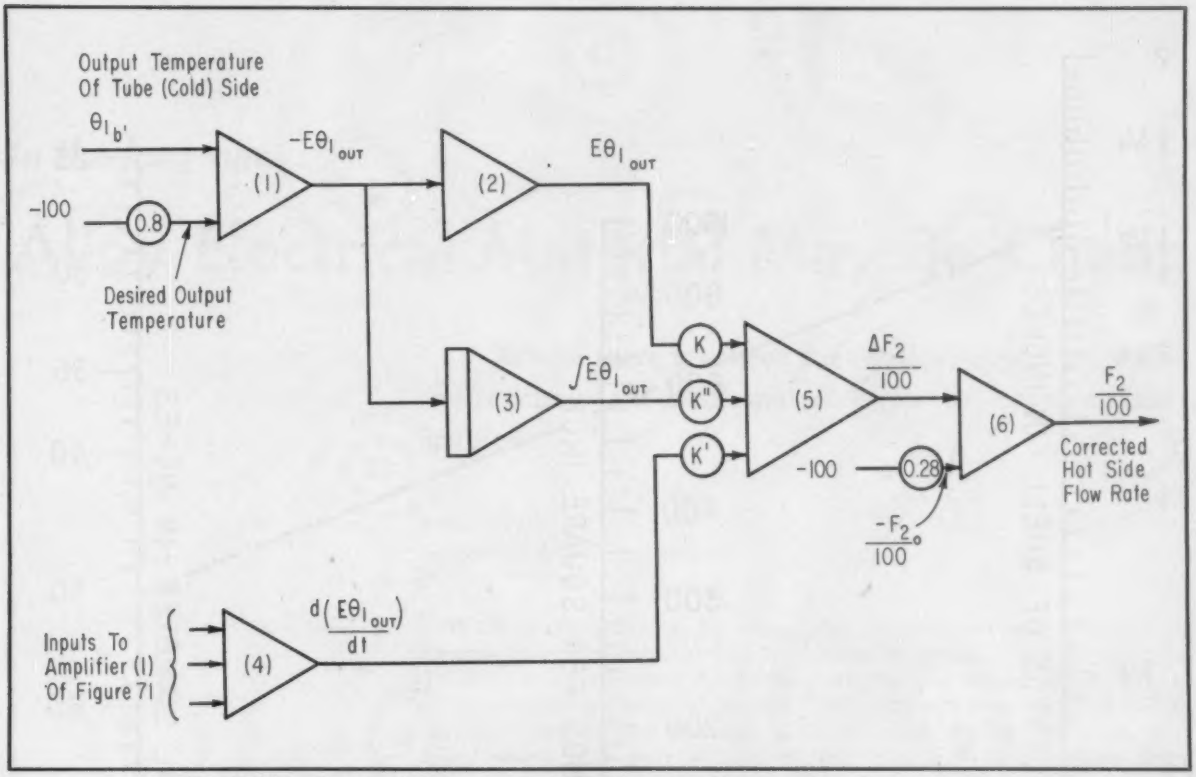

FIGURE 72—Equation (5) may be solved by this setup which represents the control system.

Figure 72 shows the computer diagram necessary to solve the controller equation assumed for our example. Referring to Part 9, this equation is as follows:

$$\Delta F_2 = KE(\theta) + K'pE(\theta) + \frac{K''}{p}E(\theta) \qquad (5)$$

where

$$E(\theta) = \theta_{i_o} - \theta_i \text{ desired}$$

The values of K, K′, and K″ set on the potentiometers must be adjusted to compensate for the time scale change previously imposed. Thus, their settings will not be the same as the converted settings graphed in Part 9.

Complete simulation of this heat exchanger on the analog computer, therefore, requires a total of five setups similar to that of Figure 71, plus another as in Figure 72. With a proper allowance for extra amplifiers as inverters, et cetra, this means a total requirement of 33 operational amplifiers of which 11 are integrators. In addition, provision for five multiplications is required. However, since one of the multiplying terms, F_2, is the same in each case, one servomultiplier would be sufficient provided it could supply the five multiplying potentiometers needed. Otherwise, additional servomultipliers would be necessary.

TABLE 2

Initial steady state conditions of temperature

Exchanger Section	Temperature, °F
a	91.3
a′	76.4
b	88.8
b′ (Output)	80.0
c	86.6
c′	77.7
d	85.0
d′	78.7
e (Output)	85.0
e′	77.8
Input (Hot)	93.0
Input (Cold)	75.0

One remaining requirement necessary to permit the simulation is the calculation of the initial conditions to be applied to the computer integrators to start the problem. These are given in Table 2. These are found by solving the steady state conditions for the exchanger with the steady state parameters given in Table 1 of Part 9. Since one volt is taken to mean 1° F. in our chosen scaling for the computer, these values also represent directly the initial condition voltages entered into the respective integrators.

Part 14 will appear in an early issue of PETROLEUM REFINER.

NOMENCLATURE

- A — area of heat transfer surface in square feet
- a, b, c, d, e — sections of shell side of exchanger
- a′, b′, c′, d′, e′ — sections of tube side of exchanger
- F — flow rate in cubic feet per hour
- h — heat transfer coefficient in BTU/(F)(Sq. ft.)(hours)
- i — as subscript, denotes input
- K — proportional control constant
- K′ — derivative control constant
- K″ — integral control constant
- o — as subscript refers to output
- p — d/dt
- Q — heat transferred in BTU/second
- t — true time in hours
- V — volume in cubic feet
- c_{p_t} — total heat capacity of the fluid in a section
- c_p — heat capacity in BTU/F. lb.
- $E(\theta)$ — error in output temperature
- ΔF — required correction in flow rate
- θ — temperature of stream in degrees F.
- ρ — density in pounds per cubic foot
- τ — time constant, second

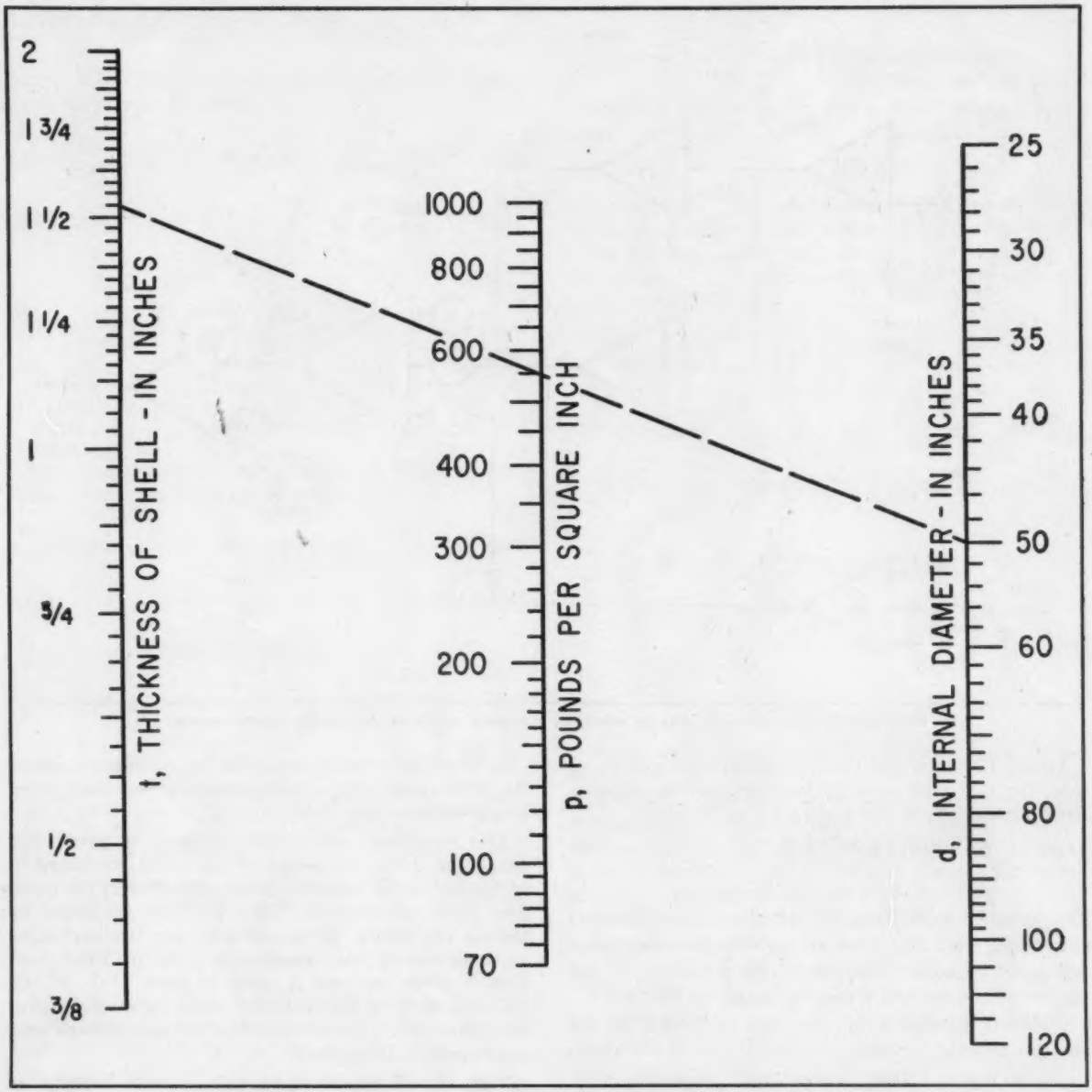

FIGURE 1—Use this handy nomograph to estimate working pressures easily and quickly.

Working Pressure of Tanks

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WHEN, FOR a hammer-welded steel tank, the thickness, t, of the shell plate and the internal diameter, d, both in inches, are known, this nomograph can be used to estimate quickly and easily the working pressure, p, pounds per square inch. Based on reliable data[1] behind the equation

$$p = \frac{18020\,t}{d},$$

this logarithmic chart was constructed by well-known method.[2]

Problem: What is the working pressure of a hammer-welded steel tank with a shell thickness of $1\frac{17}{32}$ inches and an internal diameter of 50 inches?

Solution: A straightedge through the shell thickness scale at $1\frac{17}{32}$ inches and the internal diameter scale at 50 inches intersects the pressure scale at 550 pounds per square inch.

LITERATURE CITED

[1] *Paper and Pulp Mill Catalogue*, 33rd., page 444, Fritz Publications, Inc., Chicago, 1956-57.

[2] Davis, D. S., *Nomography and Empirical Equations*, Chap. 6, Reinhold Publishing Corp., New York, 1955.

In the long run . . .

Alloy Electrical Material May Be Cheap

Where there is a need for continuous service, corrosive-resistant electrical material can be economically justified.

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OVER A PERIOD of 20 years, attempts have been made to find the best solution for combating the corrosion of electrical materials in corrosive locations. Using the logic that removal of the source is a good preventive step, many companies have accomplished much in the field of control of atmospheric pollution. Others have tried the method of shielding their equipment with protective coatings. One of the most direct approaches, however, has been the slowest to be exploited to the fullest advantage: the use of corrosion-resistant materials. While it is true that there have been very suitable products manufactured for some years, industry has been reluctant to accept them readily, and manufacturers have not adequately endorsed them.

It has been stressed that corrosion-resistant materials are costly. Generally the stainless steel alloys are priced from 6 to 8 times that of galvanized steel. On comparable items, bronze alloys cost 4 to 5 times as much as galvanized steel. Some typical comparisons are shown in Table 1.

The decision rests with the user as to whether he is willing to pay the higher initial cost and obtain long service life with low-cost maintenance, or whether his saving on first costs will provide sufficient reserve for repairs and ultimate replacement. The following comments are intended to aid in making this evaluation.

Stainless Steels. The failure of several galvanized overhead static wires due to corrosion was primarily responsible for their replacement with stainless steel strand. Most of these static grounds were over 13.8 KV tie lines which during war years, were extremely vital for maximum power needs. Since the useful life of some portions of the galvanized strand was only 4 years, the use of the stainless steel, while 6 times the cost of galvanized, was considered justifiable.

When aerial cables for both 2.4 KV and 13.8 KV service were installed, it was only natural that stainless steel be used as the messenger, since the conservative life of the cable was 30 years. Type 316 alloy was specified on the first installation for both the spinning wire and the messenger. On subsequent jobs, Type 302 messenger was used, as it had proved equally satisfactory, and also was 10 percent cheaper. The spinning wire remained Type 316, however, as earlier experience with other types had not been successful.

In a similar manner, the first pole line hardware was Type 316, and included machine bolts, double-arming bolts, washers, guy attachments, eye nuts, and lag screws. It was later found that Types 301 (later changed to 302) or 304 were equally durable, and were cheaper by 10 percent. Experiments with the low alloy Type 430 stainless proved very unsatisfactory.

The first aerial cable messenger was installed using 3-bolt clamps, similar to those used on galvanized strand. Attention was called to the avail-

ability of stainless steel preformed dead-ends and splices. Subsequent cables have been run on messengers terminated and spliced with these preformed grips, and the results have been excellent.

Bronze Alloys. Use of a bronze alloy in strand form was first tried as messengers for aerial cables, prior to changing to stainless steel. Choice of the high tensile strength aluminum bronze was based largely on the very impressive results obtained by a neighboring chemical plant where several miles of aerial cable had been in service in a highly corrosive atmosphere. Present indications are that the bronze messenger and copper-clad cable rings will easily outlast the cable.

Terminations on large open wire conductors have long been sources of trouble in refineries. The dead-end shoes used on many circuits consisted of a galvanized steel body with a malleable iron insert. The life of these fittings was frequently less than two years. This prompted a desire to obtain a more suitable clamp. A silicon bronze alloy was the best known material from which fittings were being made; therefore, dead-end shoes and jumper connectors of silicon bronze were purchased. They have been completely satisfactory and have attractive salvage value. The reduced tensile strength inherent in the alloy material has been of no consequence on sizes of wire through 750 MCM.

Conduit, being usually in contact with either earth or other metals, presents a problem to which there seems to be no single answer. Many locations, even in a refinery, lend themselves to the use of galvanized steel conduit with no adverse effects. In relatively nearby areas, it has been noted that steel conduit has failed in less than two years. This is especially true in places where acid sludge or sulfuric acid fumes are present. Cooling tower service is another location where corrosion is severe, although not as rapid. Most of this effect is attributed to the presence of large amounts of chlorine used in water treating.

Early attempts to use aluminum conduit met with failure, as the aluminum crumbled away much more rapidly than steel. It was noted that cast aluminum alloy conduit fittings showed very little corrosion in these same areas. Some effort was made to apply protective bitumastic coatings to steel conduit, but this left much to be desired, as it was costly to apply and it was necessary to keep the coating intact at all times. In some of the worst areas, corrosion broke through from inside the conduit.

The best solution to all conditions was found in the use of a silicon bronze conduit, composed of 98¼ percent copper, 1½ percent silicon, and ¼ percent manganese. Several hundred feet of this material installed in an acid sludge area during World War II was dismantled in 1956 after 13 years of service. Every foot of the conduit was in excellent condition, and all threads were clean and sharp, so that salvage value was 100 percent. Several other installations made during the same period are still in operation, requiring no maintenance whatever. Initial cost is high, being in the ratio of 4-to-1 compared to galvanized steel.

Another refinery has reported rather good usage of a cheaper red brass alloy, composed of 85 percent copper and 15 percent zinc, with a price of about twice that of galvanized steel. Further tests on this product could possibly point to substantial savings over the more expensive alloy. Some question arises as to the endurance of red brass conduit in areas where a high concentration of cathodic protection units are employed unless the conduit were bonded into the system.

Evaluation. In justifying the use of such materials from the standpoint of economics, there are five criteria one can use:

1. The minimum allowable life expectancy of the complete installation.

2. The need for continuous, uninterrupted service.

3. Routine maintenance during useful life.

4. Cost of ultimate replacement.

5. Final salvage value of material.

Certainly it would be unwise to combine various components having a calculated life expectancy of 30 years with other key components having a probable life of five years. Especially would this be so if those vital parts could be replaced only with great difficulty, or possibly not at all. This would in effect be like a chain with a weak link.

Many operations in a modern plant are dependent on uninterrupted power supply. A failure in some portion of the process can quickly cripple the entire production line. If an unscheduled outage could likely cause a loss in output amounting to thousands of dollars, then a higher initial expenditure might well be reconciled.

With present day costs of labor having spiraled upward, reduction of routine maintenance expense is often the topic on cost control programs in industry. The same trend which has enabled mechanization and automation to back out manpower per unit of production should also serve to reduce maintenance by the use of long life materials.

Replacement of partially depleted facilities must be studied to determine the full magnitude of the job. Too often conduit must be replaced at a time when the enclosed wire still has much useful life remaining. Yet it may not be feasible to reuse the wire due to damage in removing it, so that the entire bill of material must be purchased, plus of course, the labor involved.

Accompanying the rapid developments in the petrochemical industry are frequent changes in power requirements to adjust to shifting loads. This necessitates rerouting of electrical facilities to provide additional capacity, achieve flexibility, or clear sites for future units. It is at such times that the salvage value of long-life equipment can become economically attractive.

TABLE 1

Compare the costs of these corrosion-resistant electrical materials.

ITEM	COST PER HUNDRED IN DOLLARS		
	Bronze	Galvanized Steel	Stainless Steel
⅝x12 Machine Bolts	.....	$29.00	$210.00
⅝x14 Machine Bolts	.....	49.00	385.00
⅝x16 D.A. Bolts	.....	50.00	414.00
2¼x2¼x⅝ Washers	.....	6.16	40.00
¾x10 Ft. Anchor Rods	.....	330.00	2005.00
⅜ Messenger Strand	.....	7.50	47.34
¾ Conduit	$ 81.94	18.70	.....
1 Conduit	113.89	24.79	.....
1¼ Conduit	170.00	37.89	.....

Originally presented before the AIEE Conference of the Petroleum Industry, Philadelphia, Sept. 11, 1957.

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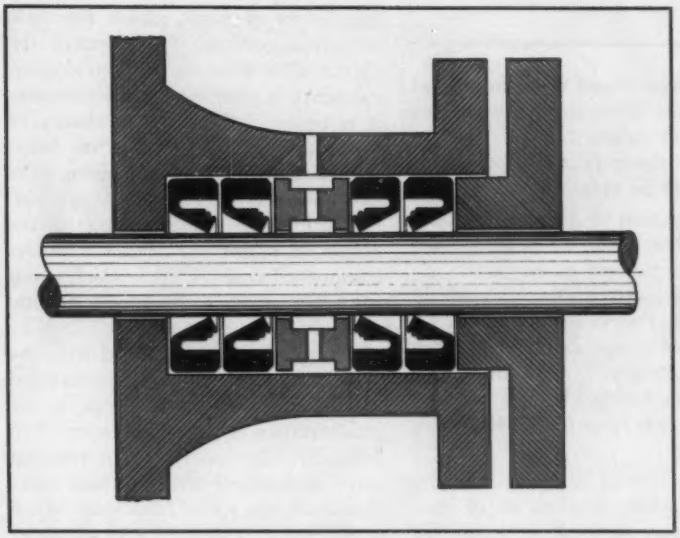

FIGURE 1—Blower stuffing box was sealed better with lip type seals than with conventional compression type packing.

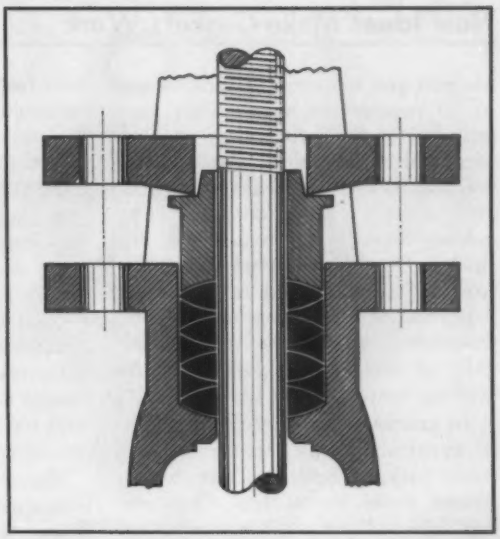

FIGURE 2—Conventional packing was replaced with cup and cone packing to stop leakage.

New Ideas to Make Gaskets Work

These case histories tell how to engineer your gasket and packing problems to insure continuous operation.

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TODAY'S TECHNOLOGY, with its emphasis on the continuous process and more severe operating conditions, demands materials and maintenance practices far more refined than those of the leather gasket and flax packing era. The continuous plant with its increasing investment is only as dependable as its weakest link. The once easily replaceable packing or gasket must now be essentially as serviceable as the equipment itself to insure continuity of operation and sufficient return on high equipment investments.

The over-all performance of either a packing or a gasket is dependent upon three basic, inter-related factors.

1. The material which must be selected in terms of the required operational characteristics.

2. The environment the packing must satisfy which includes among other things the process material, the flange surfaces, the over-all bolting arrangement, the shaft and stuffing box, and supplementary devices.

3. The physical application which comprises the human element involved in the installation and maintenance of these materials.

Material. It is conventional practice for the maintenance engineer to consider the type of material in terms of the properties that may be required for a given packing or gasket application and make a selection based upon accepted practices or previous experience. However, a more detailed evaluation may indicate that the service conditions require the use of an unconventional approach.

For instance, efforts to seal a number of blowers operating at 3600 rev-

olutions per minute with process gas at 15 pounds per square inch gage and 150 F. with four rings of conventional compression type packing resulted in excessive leakage of process materials. It was not possible to readily identify the reason for this failure. However, lip-type seals (Figure 1), normally used as a retainer for grease or oil in a bearing assembly, functioned successfully with practically no leakage as a packing in the stuffing boxes of these blowers.

In another case involving selection of material, it was necessary to test many packings before all service conditions could be satisfied. Compression type packing was not suitable for the stuffing boxes on valves in a number of applications involving corrosive or toxic process materials. Leakage could not be eliminated unless the packing was pulled up so tight that the stem became "frozen." After testing many forms of self-energizing packing, it was found that only with the tetrafluoroethylene resin cup and cone packing (Figure 2) could zero leakage be obtained and yet permit the valve to be opened or closed freely. The sensitive Halide Leak Detector and fluorinated hydrocarbon refrigerants were used to test for leakage.

While no extensive research was undertaken to establish the precise reasons for the improved performance, it is theorized that the cup and cone minimize the effects of imperfections in the surfaces of both the stem and the bore of the stuffing box due to the greater contact area.

Another example of how better packing performance can be obtained through improved materials is the use of reinforced fluoroethylene resin V-rings on reciprocating pumps. With leather V-rings in this service, it is necessary to inject supplemental lubrication at the stuffing box in order to prolong the life of the packing. With some processes it is difficult to find a lubricant resistant to the material; and with others, no contamination of the process by a lubricant is permitted.

Under these conditions, the use of the reinforced V-ring packing has eliminated the need for lubrication because of its low coefficient of friction. However, the correct choice of a filler has been found to be important because some fillers are prone to score the rod and others make the V-ring so stiff that the required sealing sensitivity cannot be obtained.

A composition of 80 percent tetrafluoroethylene resin, 15 percent glass fiber, and 5 percent molybdenum disulfide has given an average of 25 percent better service than leather in a number of reciprocating pump applications. Process conditions have ranged from 400 to 5000 psi pressure with rod speeds from 60 to 240 strokes per minute.

The selection of a gasket for new equipment under a given set of conditions is normally the responsibility of the design engineer. However, after the equipment has been in service, experience may indicate to the maintenance engineer that a change should be considered in gasket material. Such was the case with a piping system composed of ring-joint flanges and quite naturally ring-joint gaskets. The large variation in temperatures during the process cycle created a difficult leakage problem when the temperature was being raised to its maximum. The ring-type gasket was not resilient enough to compensate for the variations in contact stress brought about by the dimensional changes in the flanges and the bolts. At first glance it would appear that the maintenance engineer would be forced to accept this condition, as here is a unitary flange and gasket construction. After discussing the problem with the design engineer, it was agreed to use a more resilient metallic gasket consisting of a corrugated metal core and a corrugated metal shell without making any alterations to the surfaces of the flanges (Figure 3). This unusual use of a gasket, other than the ring-joint type in a ring-joint flange, has eliminated the leakage problem due to severe temperature changes.

The next example illustrates how maintenance personnel can be misled in their choice of a gasket material. Glass pipe or glass-lined pipe is an excellent material of construction for severe chemical service. However, the services for which it is selected, together with the fact that glass is brittle, limit the number of gasket materials that can be used. The fluoroethylene resin or fluorocarbon product envelope is an excellent gasket for these service conditions. Frequently the choice of a filler for the envelope is rubber or a reinforced rubber because it is believed there is less chance of breaking the glass with a soft filler. This leads to problems involving filler extrusion and envelope breakage particularly at the inside diameter of the gasket. A better choice is the harder compressed asbestos filler which is not subject to creep or extrusion. Sealing of such a joint is accomplished by applying a compressive load with the bolts until a reacting force is obtained sufficient to flow the envelope in the imperfections of the flange faces. With a harder filler material, this reacting force is obtained with less bolt force than with the softer filler since much of the initial bolt force with a rubber filler is used to extend the rubber without effecting a seal.

Another problem illustrates that selecting a gasket is a compromise based on consideration of all the operating conditions. It was necessary to gasket a piping system for severe chemical service at 400 psi with a temperature cycle from 300 F. to 1100 F. This definitely required a metallic gasket but one which was resilient enough to compensate for the wide temperature fluctuation. A stainless steel, spiral-wound gasket with an asbestos filler possessed all the required characteristics except that it is normally recommended for use at temperatures only up to 850 F. This is considered to be the maximum for asbestos because above 850 F. the water of crystallization is driven out and the asbestos is reduced to a powder.

A trial of this gasket in the system gave very satisfactory performance. However, it should be pointed out that once the joint is disassembled, the gasket literally falls apart. The filler turns into a powder and drops out of the gasket. Even though this change into a powder occurs at some time during the service life of the gasket, there is no adverse effect on its ability to maintain a seal because it is totally confined.

Environment. Although the packing environment is frequently not given as much attention as the material by those responsible for the maintenance of packing and gaskets, it cannot be overlooked in the approach to a seal-

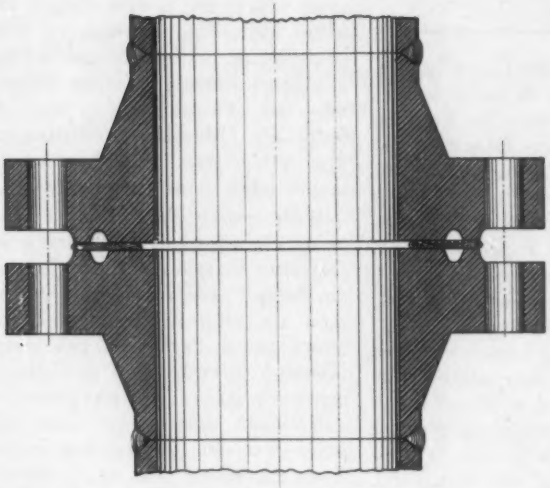

FIGURE 3—Corrugated metal gasket eliminated leakage in this ring-joint flange. It was not necessary to make any changes to the flange surfaces.

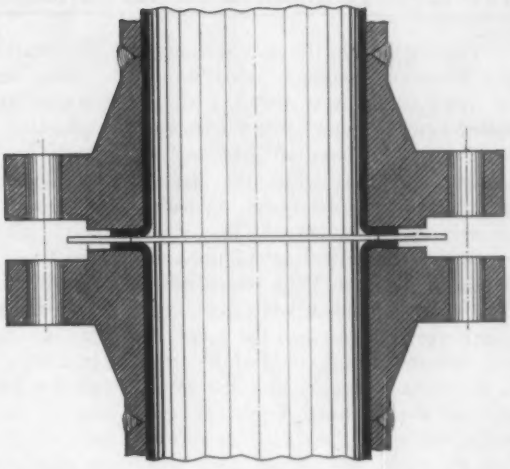

FIGURE 4—Special piping system of thin wall aluminum pipe inside carbon steel pipe has an unusual ceramic filter reinforced resin gasket.

ing problem. Undoubtedly, there are countless instances in the chemical processing industries when after trying many different materials, the problem is accepted as insurmountable. Then techniques are developed for making quick replacements to minimize the shutdown time or added capital investment is required to provide spare equipment. In many of these cases, a more complete evaluation of the problem with particular emphasis on modifying the environment might provide the desired improvement.

For example, the performance of the packing on a plunger type pump was very unsatisfactory, resulting in abnormally high maintenance costs for packing as well as frequent replacement of the scored plungers. The maintenance foreman, following the usual approach, tried many types of packing with varying degrees of success. However, none of these gave what might be considered effective service. As a result, it was necessary to investigate other conditions that might be causing the difficulty. It became apparent that the lower half of the packing was undergoing an abnormally high amount of wear as indicated by a careful measurement of the used packing. Calculations of the system showed that the weight of the plunger was too heavy for the crosshead. A hollow plunger was installed but also reamed the lower half of the packing.

No one could have criticized the maintenance engineer, had he stopped there and accepted the inevitable frequent replacement of packing, as it seemed almost impossible to make further improvement. However, additional investigation showed that ceramic plungers had recently become available for severe chemical services where metallic plungers were not completely serviceable.

Trial installations of the lighter weight ceramic plungers with several different packing arrangements gave very good results. Over a year's experience has been obtained with the ceramic plungers. The packing is now changed on a three-month frequency instead of every five days and there is no sign of wear on any of the plungers.

Occasionally, it is necessary to perform what is essentially basic research in order to improve packing performance when no reliable data are available. Such was the case involving an instrument air valve where contamination from the packing fouled the instruments controlling the continuous process. It was soon learned that small pieces of the packing were being flaked off by the rubbing action of the valve stem and extruded into the control stream. This is not unusual, but in this instance even a small amount could not be tolerated.

It was quite apparent that the commercial 16 microinch finish on the valve stem was too rough even though it appeared smooth on visual inspection. The obvious action was to improve the finish on the stem so it would not flake the packing. It required a mirror-like finish of four microinches on the valve stem to maintain a seal without causing the packing to shred from the rubbing action involved in operating the valve.

Another method of improving packing performance through attention to the environment is to supply supplemental lubrication by means of a lantern ring. Although this technique has been known and employed for many years, its use cannot be overemphasized. The nature of the packing function is such that if hydrodynamic lubrication can be obtained in a stuffing box, the lubricant will take the wear and assist as a seal. Rather than depending on the fluid being sealed or the saturant in the packing itself lubricating the shaft, it is far better to provide the lubricant from an external source.

With respect to gaskets, much could be said about flange alignment, bolting layout, and other components of environment, but perhaps the most important is that concerned with the relationship of the surface finish of the flange to the gasket. In testing a pressure vessel that had to operate with a perfect seal because of toxic process material, the flange finish became very important. The 40-inch diameter vessel had a tongue and groove joint with a surface finish of

125 microinches on the mating members. When the double-jacketed, stainless steel gasket was tested with a Halide Leak detector after the hydrostatic test, there was no evidence of leakage. However, when the flange surfaces were completely dry, the leakage was very pronounced. This confirmed the theoretical calculations of British engineers in 1936, which indicated many gasketed joints handling liquids are not sealed to the point of zero clearance but do not leak because of the surface tension and the pressure of the confined liquid at the gasket. Softer gaskets such as nickel and soft iron were tried with bolt forces far in excess of that normally recommended, but the leakage could not be stopped.

It was only possible to obtain a seal when the surfaces of the flanges were re-machined to a 63 microinch finish. Then it could be achieved with any of the different gaskets and within the recommended bolt stress.

Another example which shows why the environment must be considered in selecting a gasket material involved a special piping system consisting of a thin wall aluminum pipe inside a carbon steel pipe (Figure 4). The joints consisted of the carbon steel flange with aluminum stub ends fabricated in the field. Since these stub ends were much smaller in diameter than standard stub ends and the system was handling a chemically active material, the choice of a gasket material was definitely limited. Tetrafluoroethylene resin was suitable from the chemical resistant standpoint, but because of the small seating area it was questionable how much effect the cold flow at operating temperature would have on the ability of the gasket to maintain a seal. On this basis a ceramic fiber reinforced tetrafluoroethylene resin gasket was used on the joints in the system and has given excellent service for over twenty-two months.

Application. The third factor influencing packing and gasket performance is application. In many instances, this can be more important than either the material or the environment, but of the three factors, it is the least controllable since it involves human nature to such a large degree.

Installation of packings and gaskets is often considered to be a simple operation and one which need not be emphasized. This is a fallacious approach, for the best material and the best environment cannot give dependable service if the installation is not correct. Whether the responsibility for application be fixed with a special group of mechanics or with any mechanic in the maintenance organization, one method of improving performance is to train these personnel so that they have a good working knowledge of the fundamentals and functions of packings and gaskets. Training should not be of the on-the-job type where the experienced mechanic passes on his knowledge to the learner. This method gives no assurance that the information is adequate. A more satisfactory approach is a formal program with well-prepared lesson plans and discussions on topics such as the following: *How Packing Seals, How to Install Gaskets, How and Where the Different Types of Packings and Gaskets Are Used.* With the constant improvement in materials and techniques, this training should be a continuous program rather than a one-time course with every mechanic being given an instruction manual.

Another method of controlling the application and maintenance of packing is to set up a definite schedule for inspecting each installation. In many plants after the packing has been changed on a piece of equipment, nothing further is done until the stuffing box leaks so badly that another emergency arises. A system for inspecting stuffing boxes at periodic intervals and making minor adjustments to the assembly, will eliminate many of the effects that exist due to faulty initial installation and provide satisfactory performance. In addition, this practice will point up other maintenance difficulties such as poor bearing performance, abnormal heating of the equipment or stuffing box, and unusual operating conditions.

A second point under packing application is concerned with supplying the supplemental lubricant. The lubrication of packing, just like the lubrication of gears or bearings, should not be done at the convenience of the mechanic because this could result in either a feast or a famine situation. This applies particularly to those devices which are noncirculating such as the spring loaded grease cup or the pulsating oil pump. The packing, like any other moving machine element, must be lubricated on a scheduled frequency. Otherwise, premature failure of the packing will occur and maintenance costs become excessive.

With respect to gaskets, a major point which is often overlooked is that corrective maintenance must be done on flanged joints particularly when they are subject to high operating temperatures. Because of bolt relaxation due to both creep and thermal expansion, gasket creep and relaxation, and flange deformation that takes place in service, the bolt load applied when the system was cold is reduced during operation. This load must be restored, otherwise leakage will occur. If left unchecked for too long a period of time, this leakage may adversely affect the gasket so that a new one would have to be installed. One means of dealing with this condition is to establish a periodic follow-up for each new joint that is assembled. The schedule that is required for the reapplication of the original bolt load can only be established for each joint by experience because the amount of loss in the gasket stress is directly related to the operating conditions. However, each time that follow-up is made it will be found that the loss in gasket stress has decreased and the joint soon becomes stabilized.

Another example shows that proper installation practices must be followed even though the initial cost may appear to be high. The gaskets on nine pressure vessels exposed to varying process temperatures were being replaced about every three months due to leakage. Since a large impact wrench was used to tighten the 40 2¼-inch alloy studs on the 5-foot diameter bolt circle, it was not possible to stress the studs uniformly. As a result of this poor distribution of load on the gasket, the assembly leaked with changes in temperature. The use of micrometers was adopted to measure bolt elongation. This is a time-consuming process during the initial installation of the gasket, but an average life of two years is now obtained with these gaskets more than justifying the additional expense.

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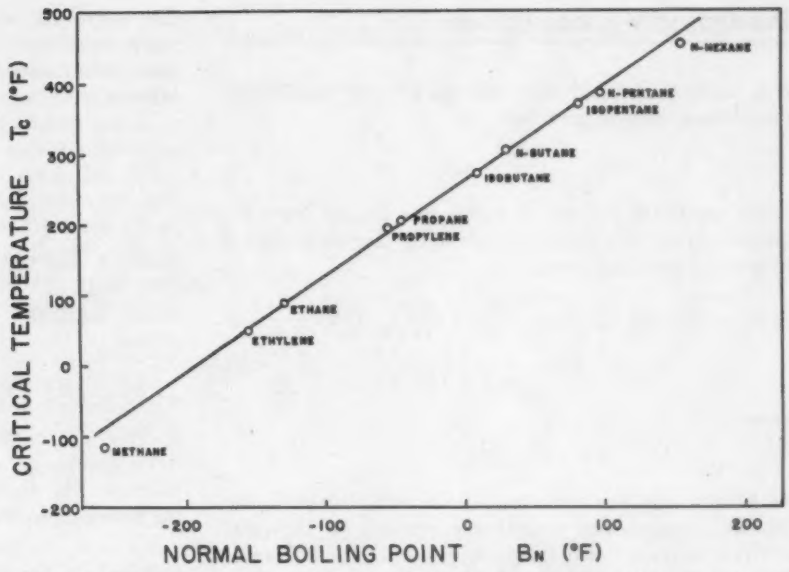

FIGURE 1—Normal boiling point correlation for light hydrocarbons: Function is linear with critical temperatures.

Predicting V-L Equilibrium Data

This method can be applied to multicomponent mixtures and can be easily adapted to computer programs.

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IN PART 1 of this series[4] a method was presented for the treatment of experimental vapor-liquid equilibrium data for binary mixtures. This part uses the equations previously developed to reduce a graphical multicomponent mixture correlation to analytical form. This analytical expression will facilitate the programming of process calculations for high speed electronic computers.

A very popular method of correlating multicomponent vapor-liquid equilibrium data employs a parameter known as the molal average boiling point, defined by Equation (1),

$$\text{MABP} = \Sigma\, z_i\, B_{n_i} \qquad (1)$$

Investigators who have used this parameter in their work include among others: Benedict, Webb, Rubin and Friend,[1] De Priester,[5] Edmister and Ruby,[6] Canjar and Edmister,[3] Papadapoulos, Pigford and Friend[7] and most recently Price, Leland and Kobayashi.[8] In each of the papers cited above, the use of the MABP concept has necessitated the use of two or more charts or graphs which offer difficulty when an attempt is made to program calculation for electronic computers. The foundation for all of this work is the Benedict-Webb-Rubin equation of state and to some extent the original paper by these authors and L. Friend.[1]

To reduce these charts and graphs to analytical form is a formidable task. However, if the scope of the work were made less ambitious than that originally assumed by Benedict and his co-worker[1] it is possible to represent vapor-liquid equilibrium data in analytical form. If the region of interest is confined to pressures below the critical pressure then the equations presented in the first paper of this series are applicable and open the way to such an analytical presentation.

Calculation of Distribution Ratios. Two numerical factors are used in computing a vapor-liquid distribution ratio. They are the fugacity coefficient for a component in a gaseous mixture and the fugacity coefficient for a component in a liquid mixture. De Priester[5] calls these coefficients the A and B factors. However, to avoid nomenclature confusion they will be referred to here as L and V factors and defined as follows.

$$L = \bar{f}^L/Px \qquad (2)$$

$$V = Py/\bar{f}^V \qquad (3)$$

Taking note that at equilibrium

$$\bar{f}_i^L = \bar{f}_i^V \qquad (4)$$

PART 2

it is easily established that the vapor-liquid equilibrium distribution ratio is given by,

$$\frac{y_i}{x_i} = L_i V_i \qquad (5)$$

An expression for the V factor has already been developed in the first paper of this series[4] and is presented here in an alternate form,

$$\ln V_i = -\ln (1 - b'P_r') + \frac{T_r'P_r'}{1 - bP_r'}\left(\frac{\partial b'}{\partial T_r'}\right)_{P_r'}\left(\frac{T_c' - T_{c_i}}{T_c'}\right) + \frac{b'P_r'}{1 - b'P_r'}\left(\frac{P_c' - P_{c_i}}{P_c'}\right) \qquad (6)$$

where

$$b' = \frac{0.1488}{(T_r' - 0.34)^2}$$

As Canjar has demonstrated in an earlier paper,[2] the critical pressures and critical temperatures of the light hydrocarbons are linear functions of normal boiling point. Figure 1 illustrates this for the case of critical temperatures. It can be shown from this that the molal average boiling point uniquely defines the pseudo-critical temperature and pressure for a given system of light hydrocarbons.

$$T_{c_i} = n + m\,B_{n_i} \qquad (7)$$

$$z_i\,T_{c_i} = z_i\,n + m\,z_i\,B_{n_i} \qquad (8)$$

and by summing over all z's

$$\Sigma\, z_i\,T_{c_i} = n\,\Sigma\, z_i + m\,\Sigma\, z_i\,B_{n_i} \qquad (9)$$

it follows that

$$T_c' = n + m\,(MABP) \qquad (10)$$

The same can be done for critical pressures. Therefore, although the V factor as given in Equation (6) appears to be a function of critical and pseudo-critical properties it can be seen from Equations (7) and (10) that for light hydrocarbons it is actually a function of the normal boiling point and MABP. It is preferable to leave Equation (6) in its more general form and extend its applicability to systems of compounds other than the light hydrocarbons.

There remains the task of developing an expression for the L factor. From the definition of activity coefficient there follows

$$\ln\frac{\bar{f}_i^{\,L}}{Px_i} = \ln\gamma_i^{\,L} + \ln f_i^{\,L} - \ln P \qquad (11)$$

In the first paper of this series[4] it was shown that

$$\ln f^L = \ln f^\square + 0.15\,(P_r - P_r^\square) \qquad (12)$$

The term $\ln f^\square$, like the vapor pressure, is a function of temperature only for any given compound. To simplify calculations somewhat the following functions have been selected,

$$\ln f^\square = A - \frac{B}{T - C} \qquad (13)$$

$$\ln P^\square = a - \frac{b}{T - c} \qquad (14)$$

Tables 1 and 2 list values for the constants in Equations (13) and (14) for each of the light hydrocarbons. Combining Equations (12), (13), and (14) with (11) one obtains

$$\ln L_i = \ln\gamma_i^{\,L} + A_i - \frac{B_i}{T - C_i} + \frac{0.15}{P_{c_i}}\left(P - e^{a_i - \frac{b_i}{T - c_i}}\right) - \ln P \qquad (15)$$

To develop an expression for $\ln\gamma_i^{\,L}$ consider a binary mixture. The Gibbs-Duhem equation can be written in the following form,

$$\frac{d\ln\gamma_1^{\,L}}{dx_2^{\,2}} = \frac{d\ln\gamma_2^{\,L}}{dx_2^{\,2}} \qquad (16)$$

and mol fraction can be written in terms of MABP,

$$x_2 = \frac{MABP^L - B_{n_1}}{B_{n_2} - B_{n_1}} \qquad (17)$$

Substituting Equation (17) into Equation (16) gives a Gibbs-Duhem equation in terms of MABP.

$$\frac{d\ln\gamma_1^{\,L}}{d\,(MABP^L - B_{n_1})^2} = \frac{d\ln\gamma_2^{\,L}}{d\,(MABP^L - B_{n_2})^2} \qquad (18)$$

Activity coefficients were computed from the original work of Benedict, Webb, Rubin and Friend[1] by selecting at given temperatures and pressures fugacity coefficients for the liquid, $\bar{f}_i/x_i$, at random values of MABP and dividing them by the fugacity coefficient at the MABP equal to the pure component normal boiling point. When the logarithm of the activity coefficients calculated in this manner are plotted against $(MABP - B_{n_i})^2$ for a given temperature there is considerable scatter and a single curve cannot be drawn through all the points. The scatter is due to inability on the part of the MABP parameter to correlate all the activity coefficients, also to the draftsmanship in drawing the curves that were finally selected by Benedict and his co-workers as representing their calculated fugacity coefficients, and due to errors in reading the graphs in the process of computing activity coefficients for this study.

Equation (18) is a powerful tool in resolving this difficult situation. Activity coefficients for any set of two components must obey Equation (18). Consider three components C_1, C_2, C_3. In Equation (18) let subscript 1 refer to any one of these components and subscript 2 to any other. Now consider a binary composed of C_1 and C_2 and study a probable plot of $\ln\gamma_1$ versus $(MABP - B_{n_1})^2$ for each of these components.

If the curve representing $\ln\gamma_1$ for C_1 is concave upward, then according to Equation (18) the curve of

TABLE 1
Constants for Liquid Fugacity Equation

	A	B	C
Methane	10.2894	1316.2	28.96
Ethane	10.5061	2101.2	64.91
Ethylene	10.2361	1756.8	73.67
Propane	10.2961	2419.1	99.92
Propylene	10.5103	2493.7	88.01
n-Butane	10.2704	2788.8	125.14
n-Pentane	10.1568	3910.2	156.18

TABLE 2
Constants for Antoine Equations

	a	b	c
Methane	10.93866	1454.2	24.9
Ethane	12.2814	3108.1	8.3
Ethylene	11.9308	2595.5	24.2
Propane	12.27286	3792.8	20.3
Propylene	12.3090	3718.3	19.3
n-Butane	12.29324	4409.0	31.8
n-Pentane	12.4259	5055.5	37.5

$\ln\gamma_2$ for C_2 should be concave downward. These two curves are so far acceptable and quite probable. Now consider a binary composed of C_1 and C_3 and study their activity coefficients. Since the curve for $\ln\gamma_1$ has already been postulated as concave upward, then according to Equation (18) the curve for $\ln\gamma_2$, this time representing C_3 must be concave downward. Once again this is acceptable and probable. However, when a binary composed of C_2 and C_3 is considered it is found the curves representing the activity coefficient versus $(MABP - B_{n_i})^2$ for each of these has already been postulated as concave downward which is impossible according to Equation (18).

There is only one curve that is universally possible for all compounds in all possible combinations of binary mixtures and that is a straight line with one and only one slope. Analytically this situation can be expressed in the form of Equation (19),

$$\ln\gamma_i^L = J\,(MABP^L - B_{n_i})^2 \qquad (19)$$

where J is a function of temperature only.

To develop the temperature dependence of J several different functions of temperature were tested. The most satisfactory correlation was obtained with the simple function,

$$J = \frac{\omega_o}{T} \qquad (20)$$

Figure 2 illustrates how random readings from the original work of Benedict, Webb, Rubin and Friend[1] agree with the final expression for the activity coefficient,

$$\ln\gamma_i^L = \frac{\omega_o}{T}(MABP^L - B_{n_i})^2 \qquad (21)$$

The slopes of the lines in Figure 2 are all the same and equal to ω_o.

Before writing a final expression for ln L it is desirable to eliminate the MABP parameter since it is not used in Equation (6), the expression for ln V. Referring to Equations (7) and (10), it follows that,

$$T_c' - T_{c_i} = m\,(MABP - B_{n_i}) \qquad (22)$$

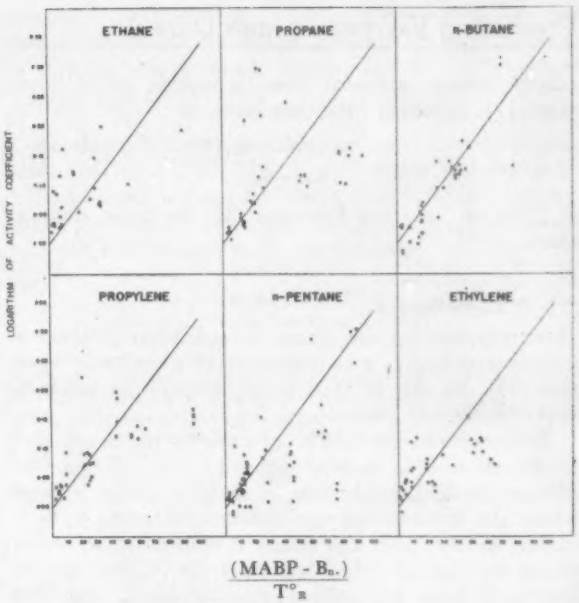

FIGURE 2—Activity coefficient correlation: How random readings from original work agree with final expression.

Enthalpy. As pointed out by Canjar and Edmister[5] the enthalpy of a liquid mixture can be computed from fugacity coefficients.

$$H'^L - H^\circ = \Sigma\, x_i\,(\overline{H}_i^L - H_i^\circ) \qquad (24)$$

where

$$H^\circ = \Sigma\, x_i\, H_i^\circ \qquad (25)$$

or

$$H^\circ = \int_{T_o}^{T} \Sigma\, x_i\, Cp_i^\circ\, dT \qquad (26)$$

To being the reference temperature for the enthalpy calculations and,

$$\frac{\overline{H}_i^L - H_i^\circ}{RT^2} = -\left(\frac{\partial \ln L}{\partial T}\right)_{P,\,T_c'} \qquad (27)$$

It follows from Equation (27) and Equation (23),

$$\overline{H}_i^L - H_i^\circ = 0.00165\,R\,(T_c' - T_{c_i})^2 - \frac{B_i RT^2}{(T - C_i)^2} - \frac{0.15\,b_i RT^2}{P_{c_i}(T - c_i)^2}\,e^{a_i - \frac{b_i}{T - c_i}} \qquad (28)$$

where $m = 1.35$ (see Figure 1). Substituting Equation (22) into Equation (21) and combining with Equation (15) the final expression for ln L is obtained.

$$\ln L_i = A_i - \frac{B_i}{T - C_i} - \ln P + \frac{0.15}{P_{c_i}}\left(P - e^{a_i - \frac{b_i}{T - c_i}}\right) + \frac{0.00165}{T}(T_c' - T_{c_i})^2 \qquad (23)$$

where

$$T_c' = \Sigma\, x_i\, T_{c_i}$$

Both Equations (23) and (6) are strictly valid in the region

$$0 < P_r < 0.8$$

$$0.6 < T_r < 1.2$$

as explained in the first paper of this series.[4]

The enthalpy of the vapor is given by the expression developed in the first paper of this series.[4]

$$H^\circ - H'^V = -\frac{RT\,T_r'\,P_r'}{1 - b'\,P_r'}\left(\frac{\partial b'}{\partial T_r'}\right)_{P_r'} \qquad (29)$$

where

$$\left(\frac{\partial b'}{\partial T_r'}\right)_{P_r'} = \frac{= 0.2976}{(T_r' - 0.34)^2} \qquad (30)$$

Analysis of the Equations. In the first paper of this series[4] it was found that for the hydrocarbon systems for which experimental data are available, the activity coefficients obey the relationship

$$\ln\gamma_1^L = \frac{\omega_{12}}{RT}\,x_2^2 \qquad (31)$$

The first question that arises concerns the consistency of Equation (21) with Equation (31). The two equations

can be written in similar form by making use of Equation (17). Equation (31) then becomes,

$$\ln\gamma_1^L = \frac{\omega_{12}}{RT}\frac{(MABP^L - B_{n_1})^2}{(B_{n_2} - B_{n_1})^2} \quad (32)$$

If Equation (21) and Equation (32) are to be identical then

$$\frac{\omega_{12}}{R\,(B_{n_2} - B_{n_1})^2} = \omega_o \quad (33)$$

However, since ω_{12} was found to be a linear function of temperature and ω_o is considered to be a constant, Equation (33) can only be valid at one temperature and is an approximation in general.

The next question that arises concerns the significance of Equation (33) and consequently the equation developed for ln L in the case of multicomponent systems where the denominator of Equation (33) $(B_{n_2} - B_{n_1})^2$ cannot be identified. The reader is referred to an earlier article by Canjar[2] which discusses the impossibility of describing p-v-t and related thermodynamic properties of multicomponent mixtures by the simple mixture rules that have been used here.

The rigorous solution to the multicomponent problem is extremely complex and only in rare cases is it worthwhile to spend the time required.
In general

$$\ln\gamma_1^L = \frac{x_2}{1-x_1}\ln\gamma_{12}^L + \frac{x_3}{1-x_1}\ln\gamma_{13}^L + \cdots + \frac{x_n}{1-x_1}\ln\gamma_{1n}^L + \Delta \quad (34)$$

Equation (34) states that the logarithms of activity coefficients for binary pairs are additive. The Δ term takes into account any deviations from this simple rule. The activity coefficient, γ_1^L, is the activity coefficient of component 1 in a multicomponent mixture. The activity coefficient γ_{11}^L is the activity coefficient for component 1 in a binary composed of components 1 and i in which the mol fraction of component 1 is the same as that of the multicomponent mixture under consideration. In the absence of experimental information, Δ must be assumed to be zero, and assuming further that Equation (31) is valid for the binary pairs, Equation (34) then becomes,

$$\ln\gamma_1^L = \frac{1}{RT}\left[\frac{x_2}{1-x_1}\omega_{12}(1-x_1)^2 + \frac{x_3}{1-x_1}\omega_{13}(1-x_1)^2 + \cdots + \frac{x_n}{1-x_1}\omega_{1n}(1-x_1)^2\right] \quad (35)$$

which simplifies to

$$\ln\gamma_1^L = \frac{(1-x_1)}{RT}[x_2\omega_{12} + x_3\omega_{13} + \cdots + x_n\omega_{1n}] \quad (36)$$

A similar equation can be written for the vapor phase. Assume, for the vapor, that an equation of the form of Equation (31) is valid for a binary pair.

$$\ln\gamma_1^V = \frac{\varepsilon_{12}}{RT}(1-y_1)^2 \quad (37)$$

Equation (36) written for the vapor phase becomes,

$$\ln\gamma_1^V = \frac{(1-y_1)}{RT}[y_2\varepsilon_{12} + y_3\varepsilon_{13} + \cdots + y_n\varepsilon_{1n}] \quad (38)$$

The ε's for the vapor phase activity coefficients can be estimated in the following manner. By definition,

$$\ln\gamma_1^V = -\ln V_1 - \ln\frac{f_1^V}{P} = \frac{\varepsilon_{12}}{RT}(1-y_1)^2 \quad (39)$$

$$\frac{\varepsilon_{12}}{RT} = \lim_{y_1 \to 0}\left[-\ln V_1 - \ln\frac{f_1}{P}\right] \quad (40)$$

As $y_1 \to 0$ $\quad T_c' \to T_{c_2}$ $\quad P_c' \to P_{c_2}$

Therefore,

$$\frac{\varepsilon_{12}}{RT} = \ln\frac{(1-b_2P_{r_2})}{(1-b_1P_{r_1})} - \frac{T_{r_2}P_{r_2}}{1-b_2P_{r_2}}\left(\frac{\partial b_2}{\partial T_{r_2}}\right)\left(\frac{T_{c_2}-T_{c_1}}{T_{c_2}}\right) - \frac{b_2P_{r_2}}{1-b_2P_{r_2}}\left(\frac{P_{c_2}-P_{c_1}}{P_{c_2}}\right) \quad (41)$$

In general ε_{12} is slightly different from ε_{21}. Either may be used as an acceptable value for both provided it is used consistently throughout all calculations.

For the liquid phase it is preferable to use the actual ω's obtained from experimental data.[4] In the absence of these, Equation (33) may be used

$$\omega_{12} = 0.0060(B_{n_2} - B_{n_1})^2 \quad (42)$$

The complexity of a process calculation using the rigorous approach can now be illustrated. Given a liquid with a known composition x_1, x_2 --- x_n at a pressure P. Find its bubble point.

Solution:

1. Compute ω for each binary pair using Equation (42).
2. Assume a trial value of T, the bubble point.
3. Compute $\ln\gamma^L$ for each component using Equation (36).
4. Compute ln L for each component using Equation (15).
5. Compute $\bar{f}^L/P$ for each component using Equation (2).
6. Compute ε for each binary pair using Equation (41).
7. Assume simultaneously trial values for y_1, y_2. --- y_n remembering $\Sigma y_i = 1.0$.
8. Compute $\ln\gamma^V$ for each component using Equation (38).
9. Compute f^V/P for each component

$$f^V/P = 1 - b\,P_r: \qquad b = \frac{0.1488}{(T_r - 0.34)^2}$$

10. Compute y for each component $\quad y = \dfrac{\bar{f}^L/P}{\gamma^V f^V/P}$

$\bar{f}^L/P$ from step 5; γ^V from step 3; f^V/P from step 9

11a. If the sum of the y's obtained in step 10 do not equal 1, repeat steps 7 to 10.
11b. If the sum of the y's obtained in step 10 equal 1 but do not equal values assumed in step 7, repeat steps 2 to 10.
11c. If the y's obtained in step 10 equal the values assumed in step 7, the problem is solved.

It can be seen that for a mixture containing only four components, five variables must be solved for simultaneously by trial and error. The solution is feasible if an electronic computer is available.

If the approximate solution is preferred it proceeds as follows:

1. Assume a value of T, the bubble point.
2. Compute ln L for each component using Equation (23).
3. Compute $\bar{f}^L/P$ for each component using Equation (2).
4. Assume a T_c' for the vapor. A corresponding value of P_c' can be computed from the equation, $P_c' = 1120 - 0.745\,T_c'$ which is valid for light hydrocarbons only.
5. Compute ln V for each component using Equation (6).
6. Compute y for each component $\quad y = \gamma^V/\dfrac{\bar{f}^L}{P}$

$\bar{f}^L/P$ is obtained from step 3.

7. Compute T_c' using y's obtained in step 6.
8a. If T_c' computed in step 7 does not equal the value assumed in step 4, repeat steps 4 to 7.
8b. If T_c' computed in step 7 equals the value assumed in step 4 but Σy_i does not equal one, repeat steps 1 to 7.

8c. If T_c' computed in step 7 equals value assumed in step 4 and $y_1 = 1$, the problem is solved.

Enthalpy Calculations. The enthalpy calculation which is consistent with the approximate solution for the vapor-liquid equilibrium problem is self-evident from Equations (24) to (30). However, if a more rigorous calculation is desired in order to be consistent with the more rigorous vapor-liquid equilibrium calculation then a slightly different procedure is followed.

Consider the thermodynamic relationship

$$\frac{H_i - \overline{H}_i}{RT^2} = \left(\frac{\partial \ln \gamma}{\partial T}\right)_{Px} \tag{43}$$

Differentiating Equations (36) and (38) with respect to temperature at constant pressure and composition, the partial molal enthalpy of a component in a multicomponent mixture is obtained.

$$\left(\frac{\partial \ln \gamma_1^L}{\partial T}\right)_{Px} = -\frac{(1-x_1)}{RT^2}[x_2\omega_{12} + x_3\omega_{13} - x_n\omega_{1n}] + \frac{(1-x_1)}{RT}\left[x_2\frac{\partial \omega_{12}}{\partial T} + x_3\frac{\partial \omega_{13}}{\partial T} + x_n\frac{\partial \omega_{1n}}{\partial T}\right] \tag{44}$$

If it is assumed that

$$\omega_{12} = \omega^\circ_{12} + rT \tag{45}$$

where r is a constant,

$$\left(\frac{\partial \ln \gamma_1^L}{\partial T}\right)_{Px} = -\frac{(1-x_1)}{RT^2}[x_2\omega^\circ_{12} + x_3\omega^\circ_{13} + \cdots x_n\omega^\circ_{1n}] \tag{46}$$

A similar equation can be written for the vapor

$$\left(\frac{\partial \ln \gamma_1^V}{\partial T}\right)_{Px} = -\frac{(1-y_1)}{RT^2}[y_2\varepsilon^\circ_{12} + y_3\varepsilon^\circ_{13} + \cdots + y_n\varepsilon^\circ_{1n}] \tag{47}$$

where

$$\varepsilon_{12} = \varepsilon^\circ_{12} + sT \tag{48}$$

It follows:

$$H_1^L - \overline{H}_1^L = -(1-x_1)\,[x_2\omega^\circ_{12} + x_3\omega^\circ_{13} + \cdots + x_n\omega^\circ_{1n}] \tag{49}$$

and

$$H_1^V - \overline{H}_1^V = -(1-y_1)\,[y_2\varepsilon^\circ_{12} + y_3\varepsilon^\circ_{13} + \cdots + y_n\varepsilon^\circ_{1n}] \tag{50}$$

For pure component gases and liquids Equations (28) and (29) become:

$$H_1^L - H_1^\circ = -\frac{B_1 RT^2}{(T-C_1)^2} - \frac{0.15\, b_1 RT^2}{P_{c_1}(T-c_1)^2}\, e^{a_1 - \frac{b_1}{T-c_1}} \tag{51}$$

$$H_1^V - H_1^\circ = -\frac{RT\,T_{r_1}P_{r_1}}{1 - b_1 P_{r_1}}\left(\frac{\partial b_1}{\partial T_{r_1}}\right)_{P_{r_1}} \tag{52}$$

Subtracting Equation (49) from (51) and Equation (50) from (52)

$$\overline{H}_1^L - H_1^\circ = -\frac{B_1RT^2}{(T-C_1)^2} - \frac{0.15\, b_1RT^2}{P_{c_1}(T-c_1)^2}\, e^{a_1 - \frac{b_1}{T-c_1}} + (1-x_1)\,(x_2\omega^\circ_{12} + x_3\omega^\circ_{13} + \cdots + x_n\omega^\circ_{1n}) \tag{53}$$

$$\overline{H}_1^V - H_1^\circ = -\frac{RT\,T_{r_1}P_{r_1}}{1 - b_1 P_{r_1}}\left(\frac{\partial b_1}{\partial T_{r_1}}\right)_{P_{r_1}} + (1-y_1)\,(y_2\varepsilon^\circ_{12} + y_3\varepsilon^\circ_{13} + \cdots + y_n\varepsilon^\circ_{1n}) \tag{54}$$

In general ω° is usually known from experimental data or assumed to be the ω which is given by Equation (42). ε is usually calculated at several temperatures in the trial and error solution for bubble points. The determination of ε° is a relatively simple calculation once ε is known as a function of temperature.

Conclusion. A correlation and procedure have been presented which enable vapor-liquid process calculation to be carried out without the use of plots, graphs or charts. Since the solution is entirely analytical it can be easily adapted to electronic computer programs.

NOMENCLATURE

A	arbitrary constant (see Equation (13)).
B	arbitrary constant (see Equation (13)).
B_n	normal boiling point.
C	arbitrary constant (see Equation (13)).
Cp°	molal heat capacity in standard state, ideal gas.
H	enthalpy of pure component.
H°	enthalpy of pure component in standard state, ideal gas.
$\overline{H}$	partial molal enthalpy.
J	constant of proportionality (see Equation (19)).
L	liquid factor, $L = \bar{f}^L/Px$.
MABP	molal average boiling point MABP $= \Sigma z_i B_{n_i}$.
P	pressure.
P_c	critical pressure.
P_r	reduced pressure, $P_r = P/P_c$.
R	gas constant.
T	absolute temperature.
T_c	critical temperature.
T_r	reduced temperature, $T_r = T/T_c$.
V	vapor factor, $V = py/\bar{f}^V$.
a	arbitrary constant (see Equation (14)).
b	arbitrary constant (see Equation (14)).
c	arbitrary constant (see Equation (14)).
f	fugacity of pure component.
$\bar{f}$	fugacity of component in nine mixture.
m	arbitrary constant (see Equation (7)).
n	arbitrary constant (see Equation (7)).
r	arbitrary constant (see Equation (45)).
s	arbitrary constant (see Equation (48)).
x	mol fraction in liquid phase.
y	mol fraction in vapor phase.
z	mol fraction liquid or vapor phase.
Δ	deviation factor (see Equation (34)).
ε	constant of proportionality (defined by Equation (37)).
ε°	zero temperature intercept of ε vs T curve.
γ	activity coefficient, $\gamma = f/f_s$.
ω	constant of proportionality (defined by Equation (31)).
ω°	zero temperature intercept of ω vs T curve.
ω_o	constant of proportionality (defined by Equation (21)).

SUPERSCRIPTS

′	mixture property.
V	vapor phase.
L	liquid phase.
□	equilibrium vapor pressure.

SUBSCRIPTS

1	component 1
2	component 2
i	ith component
n	nth component
12	binary pair components 1 and 2.
13	binary pair components 1 and 3.

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Modern Design of Steel Columns

Here is a new approach to column design for the cases where a moment is applied at the same time the column is loaded axially.

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THE STRUCTURAL ENGINEER has many factors to consider in the design of steel columns.

The simple case is where an axial load is the only force on the column. The problem becomes more complex when a moment is applied at the same time. The moment may be the result of either the eccentric action of an axial load or transverse loads. Under these conditions the column must resist direct and bending stresses simul-

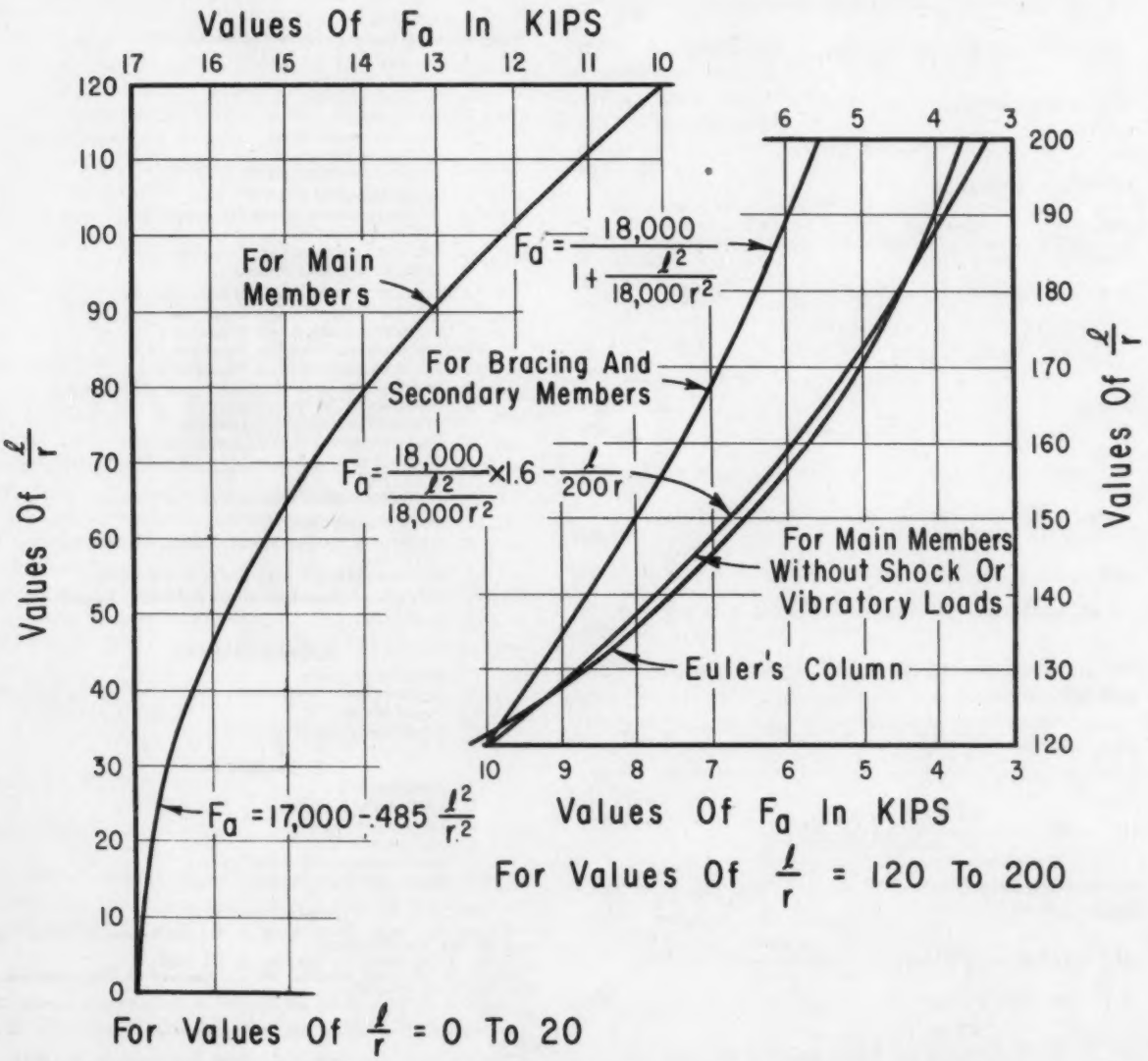
Values Of F_a In KIPS
17 16 15 14 13 12 11 10
120 110 100 90 80 70 60 50 40 30 20 10 0
Values Of $\frac{l}{r}$
For Main Members
$F_a = \frac{18,000}{1 + \frac{l^2}{18,000\,r^2}}$
For Bracing And Secondary Members
$F_a = \frac{18,000}{\frac{l^2}{18,000\,r^2}} \times 1.6 - \frac{l}{200r}$
$F_a = 17,000 - .485\,\frac{l^2}{r^2}$
For Values Of $\frac{l}{r}$ = 0 To 20
6 5 4 3
200 190 180 170 160 150 140 130 120
Values Of $\frac{l}{r}$
For Main Members Without Shock Or Vibratory Loads
Euler's Column
10 9 8 7 6 5 4 3
Values Of F_a In KIPS
For Values Of $\frac{l}{r}$ = 120 To 200

FIGURE 1—Allowable axial compressive stresses in steel members. Based on AISC 1957 specifications. Euler's formula; $F_a = \frac{P}{A} = \frac{\pi E}{(l/r)^2}$, for $\frac{l}{r}$ values ≥ 100. See Timoshenko, Vol. 2, Page 567. For structural steel E = 30,000,000 psi and the proportional limit = 30,000 psi. Factor of safety = 2.0, based on proportional limit.

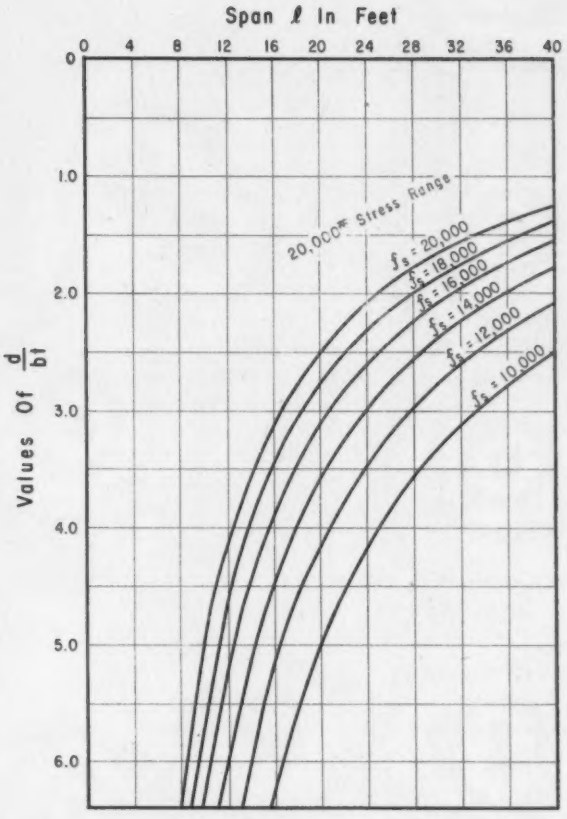

FIGURE 2—Lateral stability of beams. Allowable bending stresses for steel beams. AISC specifications (1957). For unstayed end of cantilever beam, use 2ℓ.

$$Fb = f_a = \frac{12{,}000{,}000}{\frac{ld}{bt}}$$

taneously. The maximum allowable combined unit stress cannot readily be determined.

The following factors must first be considered: The slenderness ratio for column action, and the buckling formula for beam action. When the above factors have been established, the allowable unit stresses can be determined for separate action only. When the above stresses act simultaneously, another condition must be considered.

When a column is stressed, a certain percentage by direct stress, the remaining percentage of usable capacity may be stressed by bending stress.

The above requirement is found in modern codes, and is expressed in the following formula:

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} = 1.0 \qquad (1)$$

The following formulas are used in the design of columns:

For maximum conditions: $F_a = \frac{P}{A}$ and $F_b = \frac{Mc}{I}$

Combining the stress action: $F_p = F_a + F_b$ (2)

also, $F_p = \frac{P}{A} + \frac{Mc}{I}$ (3)

substituting, $M = Pe$ and $I = r^2A$

then, $F_p = \frac{P}{A} + \frac{Mc}{I} = \frac{P}{A}\left(1 + \frac{ec}{r^2}\right)$ 3a

Equation 3a may be rearranged to suit the result we wish to achieve:

To determine area: $A = \frac{P}{F_p}\left(1 + \frac{ec}{r^2}\right)$ 3b

To determine capacity load: $P = \frac{F_p A}{1 + \frac{ec}{r^2}}$ 3c

Note: the quantity in the bracket of Equation 3a. $1 + \frac{ec}{r^2}$, represents a relation between direct and bending stress, f_a and f_b. If f_a is the axial stress, then the bending stress f_b cannot exceed $\frac{ec}{r^2} \times f_a$: that is, $f_b = \frac{ec}{r^2} f_a$. Substituting in Formula No. 1

$$\frac{f_a}{F_a} + \frac{\frac{ec}{r^2} f_a}{F_b} = 1.0$$

Clearing of fractions, multiply by $F_a F_b$

Then, $F_b f_a + \frac{ec}{r^2} f_a F_a = F_a F_b$

Factoring out f_a; $f_a(F_b + \frac{ec}{r^2} F_a) = F_a F_b$

or, $f_a = \frac{F_a F_b}{F_b + \frac{ec}{r^2} F_a}$ (4)

The allowable combined stress $F_p = f_a + f_b$

or, $F_p = \frac{F_a F_b}{F_b + \frac{ec}{r^2} F_a} + \frac{F_a F_b}{F_b + \frac{ec}{r^2} F_a} \times \frac{ec}{r^2}$

Factoring, $F_p = \frac{F_a F_b}{F_b - \frac{ec}{r^2} F_a}\left(1 + \frac{ec}{r^2}\right)$ (5)

Example: If $F_a = 14$ ksi, $F_b = 20$ ksi and $\frac{ec}{r^2} = 2.0$

Then, $F_p = \frac{14 \times 20}{20 + 2.5 \times 14}(1 + 2) = 17.5$ ksi

Figure 1 gives the allowable axial or direct stress F_a for $\frac{l}{r}$ ratios varying from 0 to 200. Figure 2 gives the allowable bending stresses F_b for various $\frac{d}{bt}$ ratios. Both graphs are based on AISC specifications.

From the above discussion, it may be observed that for a given column with an applied eccentric load, it is an easy problem to determine the maximum fiber stress in advance and compute the maximum capacity of the column.

The following problem illustrates this point:

Given: 8 — WF — 31, unstayed length 24 feet, 0 inches. ecc. $e_x = 6$ inches, $A = 9.12$ sq. in., $r_x = 3.47$ in., $r_y = 2.01$ in., $d = 8$ in., $b = 8$ in., $t_f = .403$,

$$\frac{d}{bt} = \frac{8}{6 \times .403} = 2.48.$$

$$\frac{l}{r_y} = \frac{24 \times 12}{2.01} = 143,$$

Then from Figure 1, $F_a = 8.43$ ksi

$$\frac{ld}{bt} = 24 \times 12 \times 2.48 = 712,$$

and from Figure 2, $F_b = 16.9$ ksi

$$\frac{e_x\ c_x}{r_x^2} = \frac{6 \times 4}{3.47^2} = 1.99$$

Then from Equation 5, the maximum allowable stress is:

$$F_p = \frac{8.43 \times 16.9}{16.9 + 1.99 \times 8.43}(1 + 1.99) = 12.6 \text{ ksi}$$

And from Equation 3c, the capacity load is:

$$P = \frac{F_p A}{1 + \frac{e_x c_x}{r_x^2}}$$

$$\text{or, } P = \frac{12.6 \times 9.12}{1 + 1.99} = 38.5 \text{ k.}$$

It may be shown that in any column series the allowable combined stress, for any particular value of "e" (eccentricity), does not vary greatly. The areas, weights and strength properties have a wide variation; however, the properties that determine combined stress, that is: the ratio $\frac{c}{r^2}$ has small variation. On the following page is an example to illustrate this point.

Take for example the 12 × 12 WF column series found in the A.I.S.C. Handbook. Here is one of the larger series with a wide range of 11 sections, weights varying from 65 P.S.F. to 190 P.S.F. (Table 1).

TABLE 1
Properties of 12 x 12 WF Column Series

	PROPERTIES					ECCENTRICITY			
	D	r_x	r_y	B_x*	B_y	e_x	e_y	e_xB_x	e_yB_y
SECTION	In.	In.	In.			In.	In.		
Max. 12-WF-190..	14.38	5.82	3.25	.213	.610	8	3	1.70	1.80
Max. 12-WF-65...	12.12	5.28	3.02	.217	.657	8	3	1.74	1.97

* The $\frac{c}{r^2}$ values may be found in the AISC Handbook for a limited number of sections.
The symbols used are B_x and B_y. For sections not given, see Tables 2, 3, and 4.

Given: Length = 24 ft. 0 in. For basic stresses F_a and F_b, read from Figures 1 and 2.

$$\text{Max. Col. } \frac{l}{r} = \frac{24 \times 12}{3.25} = 88.6,$$

Then from Figure 1 $F_a = 13.2$ ksi

$$\text{Min. Col. } \frac{l}{r} = \frac{24 \times 12}{3.02} = 95.5,$$

Then from Figure 1 $F_a = 12.6$ ksi

$$\frac{ld}{bt} = 24 \times 12 \times .825 = 235,$$

Then from Figure 2 $F_b = 20$ ksi

$$\frac{ld}{bt} = 24 \times 12 \times 1.62 = 467,$$

Then from Figure 2 $F_b = 20$ ksi

$$\text{Allowable stresses: } F_p = \frac{F_a F_b}{F_b + \frac{ec}{r^2} F_a}\left(1 + \frac{ec}{r^2}\right)$$

Bending about XX axis

$$\text{Max. Col. } F_p = \frac{13.2 \times 20}{20 + 1.7 \times 13.2}(1 + 1.7) = 16.85 \text{ ksi}$$

$$\text{Min. Col. } F_p = \frac{12.6 \times 20}{20 + 1.74 \times 12.6}(1 + 1.74) = 16.45 \text{ ksi}$$

Bending about YY axis

$$\text{Max. Col. } F_p = \frac{13.2 \times 20}{20 + 1.8 \times 13.2}(1 + 1.8) = 16.90 \text{ ksi}$$

$$\text{Min. Col. } F_p = \frac{12.6 \times 20}{20 \times 1.97 \times 12.6}(1 + 1.97) = 16.80 \text{ ksi}$$

From the preceding paragraph, it may be observed that the allowable combined unit stress had small variation over the entire series. It is evident that the result obtained by using the average $\frac{c}{r}$ (B value) would be sufficiently accurate to establish the maximum allowable combined unit stress for the entire series for any particular eccentric action of the load.

From the above, it may be stated that a direct approach method is possible for the designing of columns, providing the designer can establish the column series he will work in. Such is the case in structures where many columns of the same series are used. The principal variation being in the direct load and moment to be resisted.

Predicting Unit Stress. Procedure for establishing the allowable unit stress in advance:

- The allowable direct stress can be based on the average $\frac{l}{r}$ ratio for the series.
- The allowable bending stress may be approached by choosing sections in one of the wider flanged series with $\frac{ld}{bd}$ value of 600 or less. A unit stress of 20,000 can then be used. Such a choice will provide the most economical design. For extreme cases of thin and narrow flanges, a second approximation may be necessary.

Design Problem—Assume that we are working in the 12 × 12 inch wide flange series of beams.

Given: P = 120,000 lbs., $e_x = 0$, $e_y = 4$ in., l = 20 ft. 0 in.

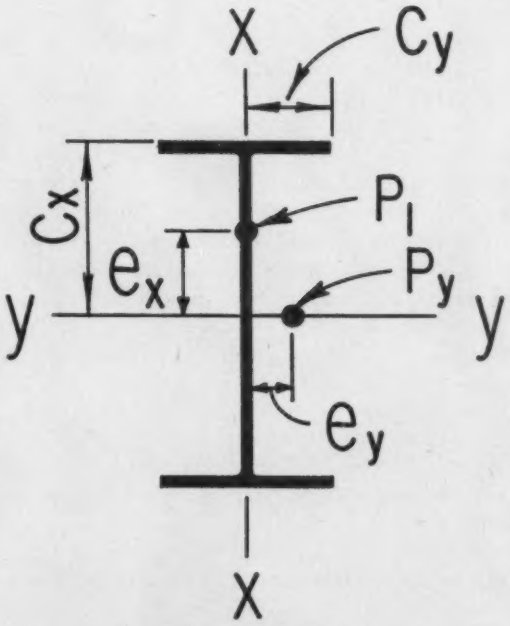

FIGURE 3—Example

If an average value for $\frac{c}{r^2}$ is used for the series:

Then, c = 6.19 in., r_x = 5.5 in. and r_y = 3.13

$$\frac{l}{r_y} = \frac{20 \times 12}{3.13} = 76.7.$$ From Figure 1, F_a = 14.12 ksi

$$\frac{ld}{bt} = \frac{240 \text{ in.} \times 13.38}{12.36 \times 1.24} = 210.$$ From Figure 2, F_b = 20.0 ksi

Average $\frac{e_y c_y}{r^2} = \frac{4 \times 6.19}{3.132} = 2.52$

Then $F_p = \frac{14.12 \times 20}{20 + 2.52 \times 14.12}(1 + 2.52) = 17.9$ ksi

And from Equation 3c, Min. Area $A = \frac{120}{17.9}$ $(1 + 2.52) = 23.6$ sq. in.

Thus, a 12 — WF — 79 provides 23.22 sq. in.

The following example illustrates the case where a moment is applied simultaneously on both axis of the column.

Case 2—Two loads acting simultaneously with double eccentricity (Figure 3).

Total $P_x + nP_x(1+n)$, Let $P_y = nP_x$
$M_x = Pe_x$ and $M_y = nP_xe_y$

Then $F_p = \frac{P_x(1+n)}{A} + \frac{P_x e_x c_x}{Ar_x^2} + \frac{n P_y e_y c_y}{A r_y^2}$

Factoring out $\frac{P_x}{A}$

$$F_p = \frac{P_x}{A}\left[(1+n) + \frac{e_x c_x}{r_x^2} + \frac{n e_y c_y}{r_y^2}\right] \quad (6)$$

Example for above condition:

Given: P_x = 200 k, P_y = 133 k, $n = \frac{P_x}{P_y} = \frac{133}{200} = .67$

e_x = 9 in., e_y = 3 in., Then $M_x = 200 \times 9 = 1800$ in. k, and $M_y = 133 \times 3 = 400$ in. k
l = 16 ft. 0 in.

For direct design: Work in the 14 × 16 WF series.

Average ratio col. = 14 WF 264

$\frac{c_x}{r_y^2} = .182$, $\frac{c_y}{r_y^2} = .467$, r_x = 6.47 in., r_y = 4.14 in.

Max. allowable direct stress:

$$\frac{l}{r_y} = \frac{16 \times 12}{4.14} = 46.5,$$ Then F_a = 15,950 psi

Sum of bending factors $\frac{e_x c_x}{r_x^2} = .182 \times 9 = 1.64$

$\frac{ne_y c_y}{r_y^2} = .67 \times .467 \times 3 = .94$

Sum = 2.58

Ratio of direct stress to bending stress $= \frac{1+n}{1.67}$ 1.67 : 2.58 = 1 : 1.55

$F_p = \frac{15.95 \times 20}{20 + 1.55 \times 15.95}(1 + 1.55) = 18.2$ ksi

Max combined allowable stress.

Area required $A = \frac{200.0}{18.2}[1.67 + 2.58] = 46.6$ sq. in.

Therefore, use 14 WF 158, A = 46.47 sq. in.

The same reasoning as discussed heretofore may be applied to pipe columns. Here the column series would be divided on the basis of pipe diameters. Each series then has a wide variation of metal thicknesses, weights and metal areas. An average $\frac{c}{r^2}$ ratio may be used for the entire series as shown heretofore.

Many members in modern structures are simultaneously subject to axial and bending loads. Much of the data for calculating the stresses for the above condition has been widely scattered or is missing. There is need for tables of condensed data to help shorten the work of establishing the allowable combined unit stress and aid the designer in quickly arriving at an economic solution for column design.

Pipe Sections. Piping, as used in refinery and petrochemical plants, is stressed by expansion and bending forces when in use conveying liquids or gases. Also, there are many cases where pipe is used as structural members. Similar data is provided for pipe sections as is given for structural sections.

Tables 2, 3 and 4 provide the designer of columns, struts and tension members with the necessary data on beam sections and pipe sections. The first column provides the number of beams in each series. Each series for structural sections are listed on the basis of depth and flange width and the pipe section series, on pipe diameters.

The remaining columns list the following data: The distance from neutral axis to the extreme fiber (c value); the radius of gyration (r value) and the ratio $\frac{c}{r^2}$ value.

TABLE 2

Average $\frac{c}{r^2}$ Values for Several Beam Series

No. of Sections In Series	Beam Series Depth—Width	PROPERTIES					
		c_x	r_x	$\frac{c_x}{r_x^2}$	c_y	r_y	$\frac{c_y}{r_y^2}$
5	36 x 16½ WF	18.12	15.0	.081	8.27	3.65	.62
5	36 x 12 WF	18.08	14.47	.086	6.01	2.45	1.00
3	33 x 15¾ WF	16.63	13.79	.088	7.90	3.48	.65
3	33 x 11½ WF	16.65	13.39	.093	5.77	2.35	1.04
3	30 x 15 WF	15.06	12.57	.095	7.52	3.34	.67
4	30 x 10½ WF	15.00	12.10	.102	5.25	2.14	1.15
3	27 x 14 WF	13.54	11.31	.106	7.01	3.12	.72
3	27 x 10 WF	13.53	10.96	.113	5.00	2.08	1.15
3	24 x 14 WF	12.24	10.34	.115	7.02	3.19	.69
3	24 x 12 WF	12.08	10.12	.117	6.02	2.66	.85
3	24 x 9 WF	12.04	9.78	.126	4.51	1.89	1.26
3	21 x 13 WF	10.62	8.99	.131	6.53	3.01	.72
2	21 x 9 WF	10.43	8.55	.143	4.48	1.95	1.18
3	21 x 8¼ WF	10.57	8.59	.143	4.13	1.74	1.36
3	18 x 11¾ WF	9.16	7.75	.153	5.90	2.73	.79
4	18 x 8¾ WF	9.05	7.52	.160	4.39	1.96	1.14
3	18 x 7½ WF	9.06	7.41	.165	3.77	1.61	1.45
2	16 x 11½ WF	8.12	6.90	.117	5.76	2.69	.79
4	16 x 8½ WF	8.04	6.68	.180	4.26	1.92	1.15
4	16 x 7 WF	8.03	6.63	.183	3.51	1.51	1.54

Example Using Table 2: Determine the maximum combined unit stress for the 24 × 12 wide flange series. Three sections are available.

Given: e_x = 18 in., F_a = 16.0 ksi, F_b = 20 ksi

From Table 2, $\frac{c_x}{r_x^2} = .117$, Then $\frac{ec_x}{r_x^2} = 18 \times .117 = 2.11$

TABLE 3

Average $\frac{c}{r^2}$ Values for Several Beam Series

No. of Sections In Series	Beam Series Depth—Width	PROPERTIES					
		c_x	r_x	$\frac{c_x}{r_x^2}$	c_y	r_y	$\frac{c_y}{r_y^2}$
20	14 x 16 WF	7.93	6.59	.183	7.91	4.08	.47
7	14 x 14½ WF	7.18	6.23	.185	7.31	3.73	.53
2	14 x 12 WF	7.05	6.11	.189	6.00	3.01	.67
3	14 x 10 WF	7.03	6.02	.194	5.02	2.46	.83
3	14 x 8 WF	6.90	5.86	.200	4.01	1.91	1.10
3	14 x 6¾ WF	7.00	5.83	.206	3.37	1.46	1.58
11	12 x 12 WF	6.44	5.46	.216	6.12	3.11	.63
2	12 x 10 WF	6.06	5.26	.228	5.00	2.50	.80
3	12 x 8 WF	6.03	5.15	.227	4.02	1.94	1.06
3	12 x 6½ WF	6.04	5.11	.232	3.27	1.47	1.52
9	10 x 10 WF	5.25	4.46	.264	5.08	2.59	.76
3	10 x 8 WF	4.97	4.27	.273	4.00	1.98	1.02
3	10 x 5¾ WF	5.04	4.26	.276	2.88	1.31	1.68
6	8 x 8 WF	4.18	3.57	.33	4.04	2.06	.95
2	8 x 6½ WF	4.00	3.43	.34	3.26	1.61	1.26
2	8 x 5¼ WF	4.03	3.39	.35	2.63	1.18	1.82
3	6 x 6 WF	3.10	2.66	.46	2.95	1.50	1.31
3	5 x 5 WF	2.53	2.14	.55	2.53	1.27	1.57
1	4 x 4 WF	2.08	1.70	.72	2.08	.98	2.17
3	12 x 4 B	6.08	4.81	.26	2.00	.81	3.05
3	10 x 4 B	5.06	4.05	.31	2.00	.83	2.90
2	8 x 4 B	4.03	3.25	.38	2.00	.85	2.80
2	6 x 4 B	3.06	2.53	.48	2.00	.93	2.31

From Equation 5, $F_p = \frac{16 \times 20}{20 + 2.11 \times 16}(1 + 2.11) = 18.5$ ksi

This is the maximum allowable combined stress for the above eccentricity. This stress can be applied to any of the sections in this wide flange series.

Example Using Table 3: Determine the column size for the following condition:

Given: $l = 24$ feet, $e_y = 6$ inches, $P = 100$ k, Avg. $r_y = 2.6$

Working in the 10×10 WF series: $\frac{l}{r} = \frac{288}{2.6} = 111$, $F_a = 11$ ksi, $F_b = 20$ ksi

From Table 3: $\frac{c_y}{r_y^2} = .76$, $\frac{e_y c_y}{r_y} = 6 \times .76 = 4.56$

From Equation 5, $F_p = \frac{11 \times 20}{20 + 11 \times 4.56}(1 + 4.56) = 17.3$ ksi

From Equation 2c, $A = \frac{100}{17.5}(1 + 4.56) = 31.8$ sq. in.

Using a 10 WF 112 column, $A = 32.92$ sq. in.

It seems that a 12×12 WF beam series would be more economical where:

$\frac{l}{r_y} = \frac{24 \times 12}{3.13} = 92$, $F_a = 12.9$ ksi, $F_b = 20$ ksi, $e_y = 6$ in., $\frac{c_y}{r_y^2} = .63$,

$\frac{e_y c_y}{r_y^2} = 6 \times .63 = 3.78$, $F_p = \frac{12.9 \times 20}{20 + 12.9 \times 3.78}(1 + 3.78) = 17.9$ ksi

$A = \frac{100}{17.9}(1 + 3.78) = 26.8$ sq. in.

Therefore, use a 12 WF 92 beam series.

TABLE 4

Average $\frac{c}{r^2}$ Values for Each Pipe Series

No. of Sections In Series	Nominal Pipe Dia.	Constant Pipe Dia. O.D.	PROPERTIES		
			$c = \frac{O.D.}{2}$	r	$\frac{c}{r^2}$
6	1ϕ	1.32	.66	.41	3.97
5	1½ϕ	1.90	.95	.61	2.61
9	2ϕ	2.38	1.19	.77	2.03
6	2½ϕ	2.88	1.44	.93	1.66
13	3ϕ	3.50	1.75	1.19	1.23
11	3½ϕ	4.00	2.00	1.34	1.11
19	4ϕ	4.50	2.25	1.50	1.00
8	5ϕ	5.56	2.78	1.82	.85
14	6ϕ	6.63	3.22	2.25	.64
22	8ϕ	8.63	4.37	2.93	.51
19	10ϕ	10.75	5.37	3.67	.40
22	12ϕ	12.75	6.37	4.37	.33
19	...	14.0	7.00	4.81	.30
21	...	16.0	8.00	5.48	.27
17	...	18.0	9.00	6.12	.24
18	...	20.0	10.00	6.78	.22
17	...	24.0	12.00	8.22	.18
6	...	30.0	15.00	10.44	.14

Example Using Table 4: Determine the maximum allowable combined stress for the 10 inch pipe series, if the basic, allowable unit stresses have been established.

As: $F_a = 14.0$ ksi and $F_b = 18$ ksi.

If the load P is 7 inches eccentric and the pipe deflection from the weight is another 1 inch eccentric, then $e = 7 + 1 = 8$ in.

From Table 3, $\frac{c}{r^2} = .40$, then $\frac{ec}{r^2} = 8 \times .4 = 3.2$

From Equation 5, $F_p = \frac{14 \times 18}{18 + 3.2 \times 14}(1 + 3.2) = 16.9$ ksi

If a pipe is used with a metal area of 9.18 square inches, then the maximum load capacity for the above condition is:

$$P_{max} = \frac{F_p A}{1 + \frac{ec}{r^2}} = \frac{16.9 \times 9.18}{1 + 3.2} = 37.0 \text{ k}$$

LIST OF SYMBOLS

f_a — For direct stress acting alone, less than maximum.
F_a — For direct stress acting alone, maximum.
f_b — For bending stress acting alone, less than maximum.
F_b — For bending stress acting alone, maximum.
F_p — Maximum allowed combined stress.
r — Radius of gyration about axis of bending.
c — Distance from neutral axis to extreme fiber.
B_x, B_y equals ratios of $\frac{c}{r^2}$ on XX and YY axis respectively.
e — eccentricity.
P and nP are column loads acting eccentrically and simultaneously on the XX and YY axis respectively.

Select Your Pumps by Specific Speed

Use "specific speed" for selecting pumps and to check your process design.

John K. Jacobs
United Engineers and Contractors Inc.
Philadelphia, Penn.

SPECIFIC SPEED can be used to (a) avoid cavitation troubles (b) to select the most economic pump for a given process layout and (c) to assist in redesigning process conditions.

For single-stage side-suction impellers, the suction specific speed is expressed by

$$S = N \frac{Q^{½}}{H^{¾}} \qquad (1)$$

and would be dimensionless if consistent units were used. Pump manufacturer practice is to express Q in gpm of pump capacity, N in rpm of pump speed, and H in feet of liquid. (The values of S obtained from these units may be converted to the dimensionless ratio by dividing by 17200).

H refers to the net positive suction head above the liquid vapor pressure available (NPSH) measured at the pump suction flange and is given by

$$H = h_a \pm h_h - h_p - h_v \qquad (2)$$

where h_a is the ambient pressure at the liquid surface, h_h is the static head between the liquid surface and the pump center-line, h_p is the combined entrance, piping, and fittings friction loss, while h_v is the proper pressure at the pumping temperature, and all these are expressed in feet of liquid.

There is also an NPSH requirement for each pump which is largely a function of impeller design and this pump NPSH represents the drop in pressure between the pump suction flange and the impeller vane tips. When this drop exceeds the available NPSH a momentary flashing of the liquid occurs. Not only does the flashed vapor reduce pumping capacity but the bubbles move at high velocities to regions of lower pressure where they collapse violently. The resulting cavitation may cause severe impeller erosion as well as serious noise and vibration in the pump.

Specific speeds of centrifugal pumps may vary from 1100 to 15000 but values above 12000 are not considered commercially practical. Values between 8500 and 12000 are occasionally used with highly designed impellers but are preferably avoided if pump selection or process layout and costs permit use of a specific speed below 8500. These values apply to cold water and are generally conservative for other liquids. An NPSH correction can be made for hydrocarbons.[1] Specific speed limits are available from manufacturers of pumps. Useful discussions of specific speed are available.[2, 3]

The accompanying nomograph permits a rapid estimate of specific speed for any given process layout. Scale N shows pump rpm and the common 60-cycle direct motor driven speeds. Scale Q shows the single and double suction pump capacity and scale H the available NPSH.

Example: Assume a reboiler pumping service of 400 gpm using a 3500-rpm single suction pump, with a reboiler liquid level 18 feet above the pump and friction from entrance loss, pipe loss and fittings loss adding up to 5 feet. What information is available?

Since the liquid is at the boiling point $h_a = h_v$ and from equation (2), H = 13 feet. Use of the nomograph shows a specific suction speed of 10200 which is a little above a conservative figure for avoiding cavitation. Assuming that this is a new installation, the following are some of the possibilities that might be investigated and costs compared:

- Check pump manufacturers for NPSH requirements of impellers that will deliver at specified conditions with this particular fluid.
- Enlarge suction piping to give h_p of 2 feet.
- Raise reboiler or lower pump to give h_h of 21 feet.
- Select pump for 2900 rpm (or 1700 if 2900 is unavailable).
- Use double-suction pump.
- Pump 300 gpm.

About the Author

JOHN K. JACOBS is a process engineer with United Engineers & Constructors, Inc., Philadelphia. With the company since 1954, his duties include both process design and economic studies. His background in the process industries spans some 18 years with such companies as Electric Furnace Products Company, Allied Chemical & Dye Corporation's Barrett division, and Industrial Rayon Corp. He holds B.S. and M.S. degrees from Massachusetts Institute of Technology, and is a registered professional engineer in Pennsylvania.

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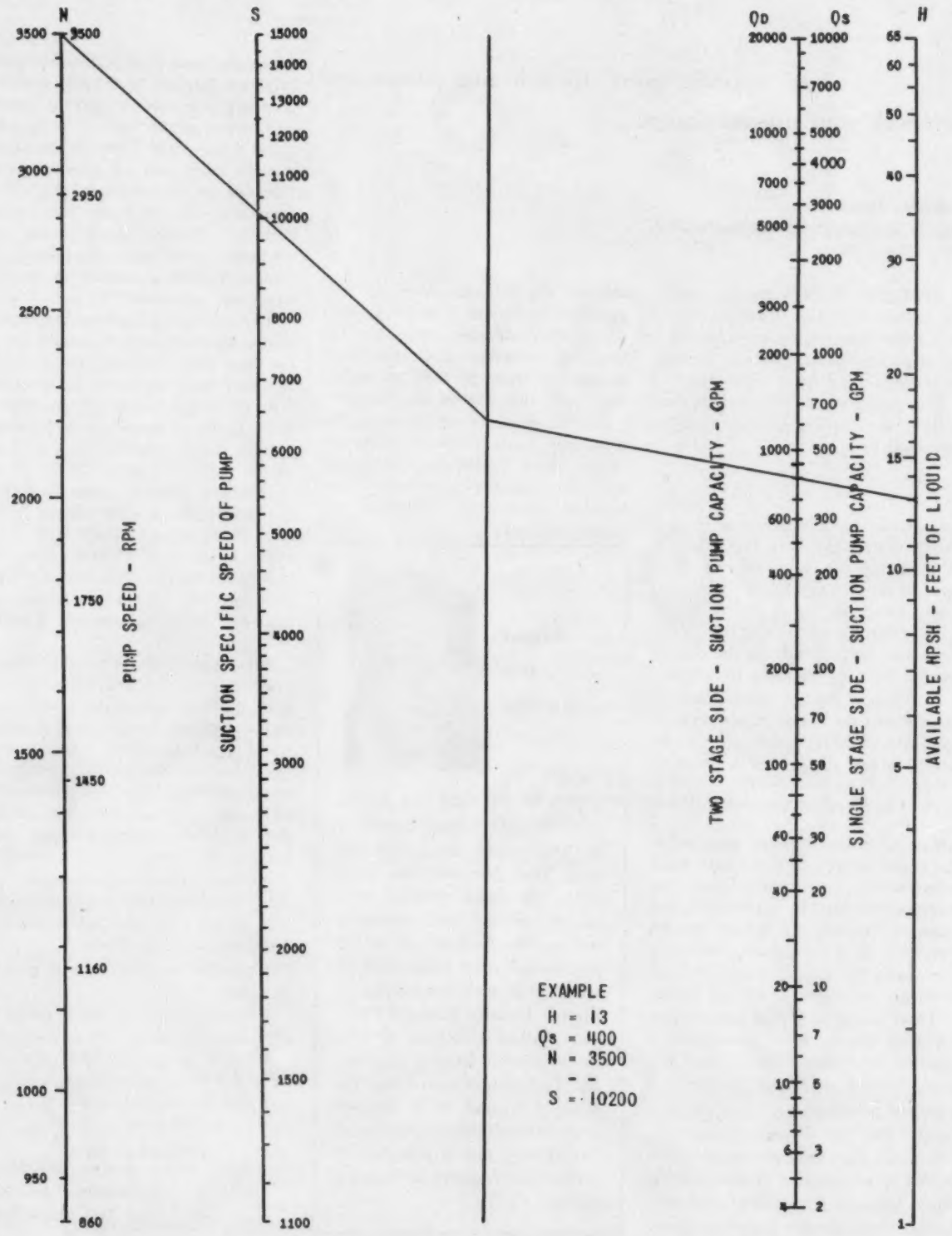
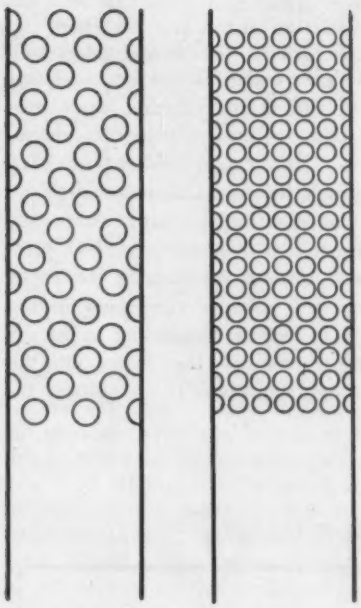
See nomogram on Page 146

Specific Speed from NPSH



Calculate Condenser Pressure Drop



TUBEBANK NO. 1 TUBEBANK NO. 2

FIGURE 1—Tubefields used in pilot test unit. Tubebank 1, ¾-inch tubes on 45-degree 1-inch pitch with 8 tubes in a vertical row. Tubebank 2, ½-inch tubes on 90-degree, ⅝-inch pitch with 17 tubes in a vertical row. Tube length is 4 inches.

Use this new empirical method for correlating two-phase pressure drop in condensers.

John E. Diehl
Research Engineer
C F Braun and Company

A NEW METHOD has been developed correlating the two-phase pressure drop data in downflow condensers with an average deviation of 10 percent. This correlation serves as a basis for predicting pressure drop during condensation and deviates from actual test data by an average of 11 percent. Condensation pressure drop now can be predicted by a stepwise computation using this two-phase correlation.

Prediction of pressure drop through horizontal tubebanks, with condensation, has long been a problem facing design engineers. Examples of two-phase downflow through horizontal tubebanks are:

- Surface condensers in steam power plants.
- Box or bathtub condensers in refineries.

Since these condensers are usually found in vacuum or low-pressure service, allowable pressure drop is a controlling factor in design.

At the time these studies were started, the method of Lockhart and Martinelli[5] was the most generally accepted correlation for two-phase flow pressure drop. The purpose was to check the applicability of this corre-

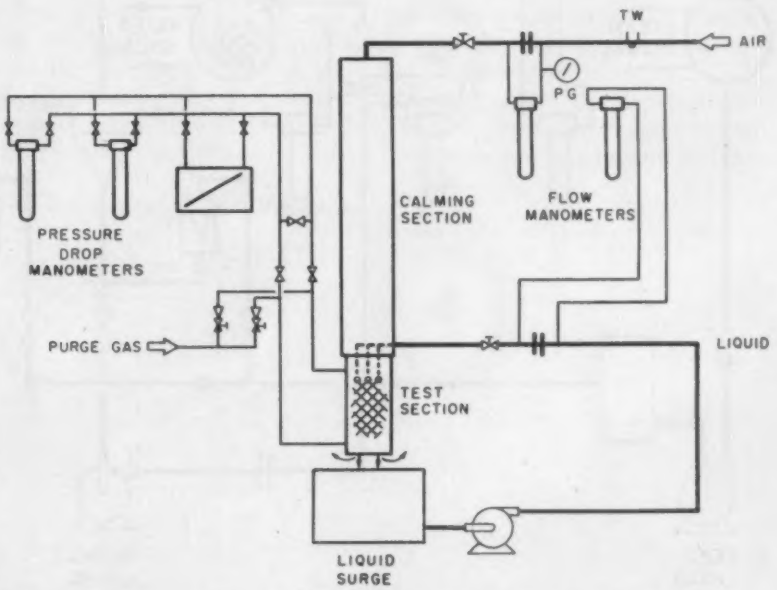


FIGURE 2—Flow diagram of the unit used for tests at atmospheric pressure.

lation for two-phase downflow inshell, and if necessary, to develop a new correlation.

Concurrent with this work on two-phase flow inshell, Chenoweth and Martin[3] developed a method for predicting two-phase flow pressure drop in pipes. Their method correlates a large number of tests with greater accuracy than the earlier methods. Chenoweth and Martin used basically the same correlating parameters as the ones developed in this study for inshell two-phase downflow.

TEST UNITS

The data were obtained in two test units. The first unit could handle only air-liquid systems at atmospheric pressure. In this unit both inline and staggered tubefield layouts were studied. In the vaporization and condensation pilot plant, adiabatic two-phase data at different pressures were obtained, as well as pressure-drop data during condensation. Only the staggered tubefield layout was studied in the pilot plant. Figure 1 shows the layout and gives the dimensions of the two tubebanks used in this study.

The two tubebanks studied in the atmospheric unit were dummy bundles with solid rods for tubes. The two faces at the tube ends of the dummy tubebanks were fabricated from clear plastic to permit observation of the flow patterns. The dummy bundle with staggered layout was an exact duplicate of the test bundle used in the pilot plant.

Atmospheric Test Unit. The arrangement of the tubebank, the circulating system, and the means for measuring flow rates, temperatures and pressures are shown in Figure 2. The air entered through a calming section to establish a uniform flow pattern at the point of entry into the tubebank. The water entered through the top horizontal row of tubes which formed a special liquid distributor. A series of tests ascertained that the liquid distribution was uniform.

Pilot Plant. Two-phase tests were made on several vapor-liquid systems at different pressures in the vaporization and condensation pilot plant.

For tests with methane as the gas stream, the reboiler remained idle, methane flowed through the gas recycle system, and the liquid flowed through the liquid recycle system. For pentane vapor-liquid two-phase tests, the reboiler generated the vapor phase. The vapor flowed through the test section in the first condenser and condensed in the second condenser. The tube surface in the first condenser was held at the reboiler vapor temperature to prevent vapor condensation. The liquid phase recycled through the liquid recycle system.

Condensation pressure-drop was measured with pentane at three pressures. Various fractions of the vapor from the reboiler condensed in the first condenser, depending upon the temperature of the water flowing through the tubes. The conditions to-

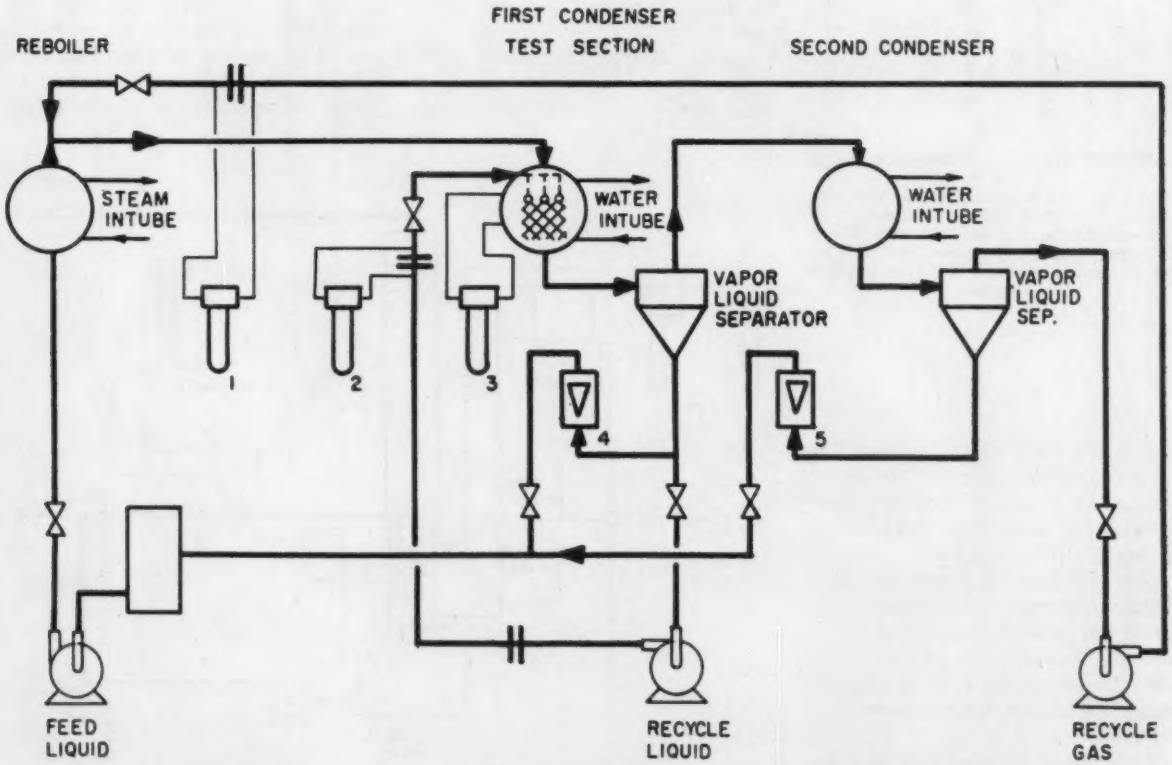


FIGURE 3—Flow diagram for pressure tests in the vaporization and condensation pilot plant.

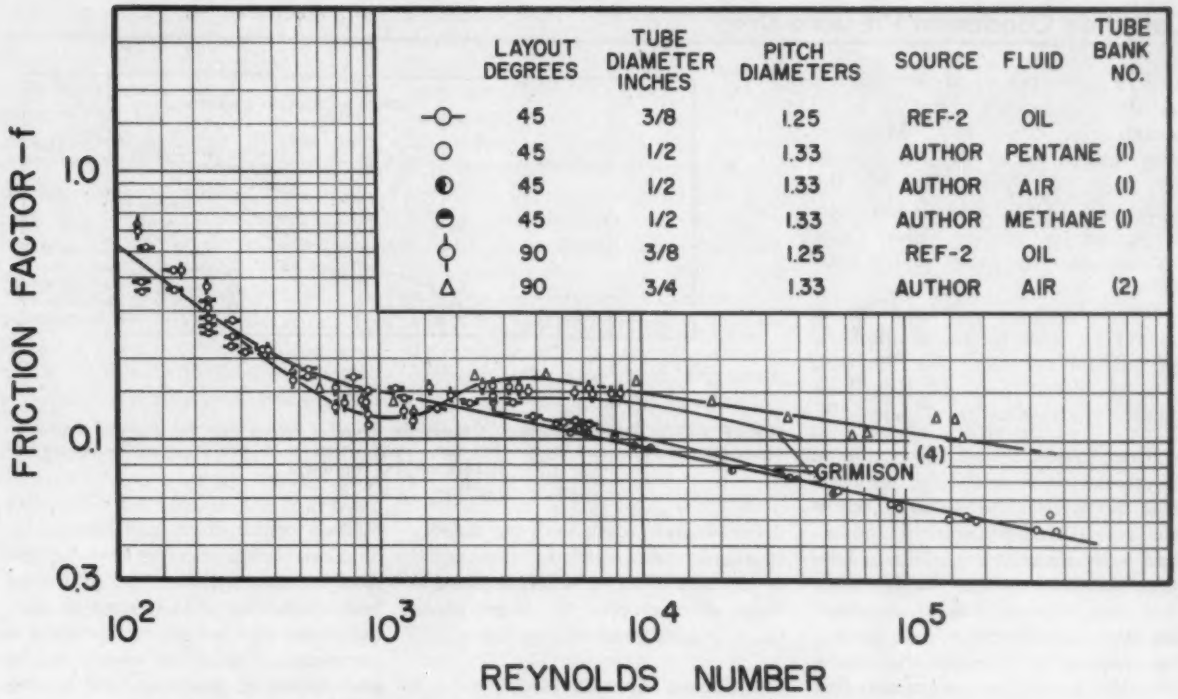


FIGURE 4—Single phase friction factor calibration of the tubefields plotted against Reynolds number.

ward the bottom of a large downflow condenser were simulated by recycling condensate during condensation tests.

Standard orifice meter runs, 1 and 2 in Figure 3, were used to meter the recycle stream rates. Calibrated rotameters, 4 and 5 in Figure 3, were used to measure vapors condensed in the test bundle and in the second condenser.

TESTS

Three types of tests were made: (a) Single-phase calibration tests were made on the tubebanks in both test-units, (b) A large number of adiabatic two-phase tests were made in both test units, and (c) pressure-drop measurements were made during condensation in the pilot plant tubebank.

• Single-Phase Tests. To check the single phase friction factor, both dummy tubebanks were calibrated with air at atmospheric pressure. Methane and pentane vapor were used to calibrate the staggered tubebank in the pilot plant. Figure 4 shows the experimental friction factors plotted against Reynolds number. The data agree well with the data of Bergelin, Brown and Doberstein[2] and of Grimison.[4] The present data extend the range of experimentally-determined friction factors to Reynolds numbers as high as 4×10^5.

• Two-Phase and Condensation Tests. A total of 353 adiabatic two-phase pressure-drop tests were made in the atmospheric unit and in the pilot plant. 39 pressure drop tests were made for the condensation of pentane in the pilot plant. In these tests, liquid properties covered a wide range—densities from 33 to 82 pounds per cubic foot, viscosities from 0.2 to 160 centipoises, and surface tensions from

TABLE 1—Range of Test Variables

SYSTEM	Tube-Bank	Number Tests	Pressure PSIA	Liquid Volume Percent	Re_G*	$\frac{\rho_L}{\rho_G}$	μ_L	σ_L
Air-water	1	90	14.7	.009–99.4	18,000–1,000,000	830	1.0	73
Air-water*	1	23	14.7	.005–21	18,000–180,000	830	1.0	42
Air-water*	1	17	14.7	.005–21	18,000–180,000	830	1.0	27
Air-absorption oil	1	19	14.7	.028–3.1	16,000–150,000	680	2.5	33
Air-62 percent sugar solution	1	16	14.7	.059–1.8	23,000–180,000	1070	100–600	74
Air-52 percent sugar solution	1	15	14.7	.059–1.8	23,000–180,000	1020	24	73
Air-40 percent sugar solution	1	17	14.7	.059–1.8	23,000–180,000	970	7.7	73
Air-29 percent sugar solution	1	15	14.7	.059–1.8	23,000–180,000	920	3.2	73
Air-water	2	49	14.7	.0016–26	4,000–430,000	830	1.0	73
Pentane-pentane	1	11	30	.082–7.0	100,000–660,000	121	.26	10
Pentane-pentane	1	31	50	.082–7.0	100,000–660,000	62	.23	8
Pentane-pentane	1	17	90	.082–7.0	100,000–660,000	33	.20	6
Methane-pentane	1	7	17.9	4.9–55.5	45,000–240,000	322	.29	13
Methane-propylene glycol	1	7	9.3	.24–4.7	30,000–230,000	2800	20	40
Methane-propylene glycol	1	12	15	.24–4.7	30,000–230,000	1370	24	40
Methane-propylene glycol	1	7	23	.24–4.7	30,000–230,000	890	27	40
Pentane†	1	39	30–90	.....	100,000–700,000	33–121	....	....

* With wetting agent. † Condensation tests.

6 to 74 dynes per square centimeter. Gas densities ranged from 0.02 to 1.0 pounds per cubic foot. Mass-flow rates ranged up to 700,000 pounds, per hour per square foot for the liquid and 120,000 pounds per hour per square foot for the vapor. Table 1 summarizes the range of test conditions.

The operating procedure was in general the same for the atmospheric test unit and the pilot plant. The data were considered acceptable if the heat balance checked within 6 percent.

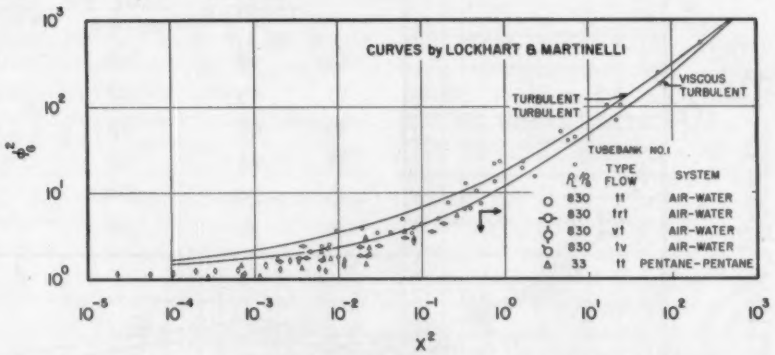


FIGURE 5—Test data of Tubebank 1 shows the downflow inshell data for air-water system at atmospheric pressure, and the pentane vapor-liquid system at 90 psia evaluated by the method of Lockhart and Martinelli.

• **Flow Types.** For horizontal pipe Alves[1] described and gave approximate boundaries for seven different flow types. In order of their appearance with increasing gas flow, these types are designated as, bubble flow, plug flow, layered flow, wavy flow, slug flow, annular flow, and misting flow. Visual studies of the inshell downflow two-phase system revealed only the last two types in the range applicable to condensers.

To obtain data at high liquid-to-gas ratios and high liquid rates, test measurements were made with the dummy tubebank submerged in the liquid surge-tank. The measured pressure drops were corrected for mixed phase static head whenever significant.

Two-Phase Correlation. Figure 5 shows the downflow inshell data for the air-water system at atmospheric pressure, and the pentane vapor-liquid system at 90 psia evaluated by the method of Lockhart and Martinelli. The correlation requires that the test data be classified as turbulent-turbulent, transition-turbulent, and viscous-turbulent. As a matter of interest, the turbulent-turbulent and viscous-turbulent curves of Lockhart and Martinelli were plotted for two-phase flow in horizontal pipes. Although the geometry and flow direction of the inshell and in-pipe systems differ radi-

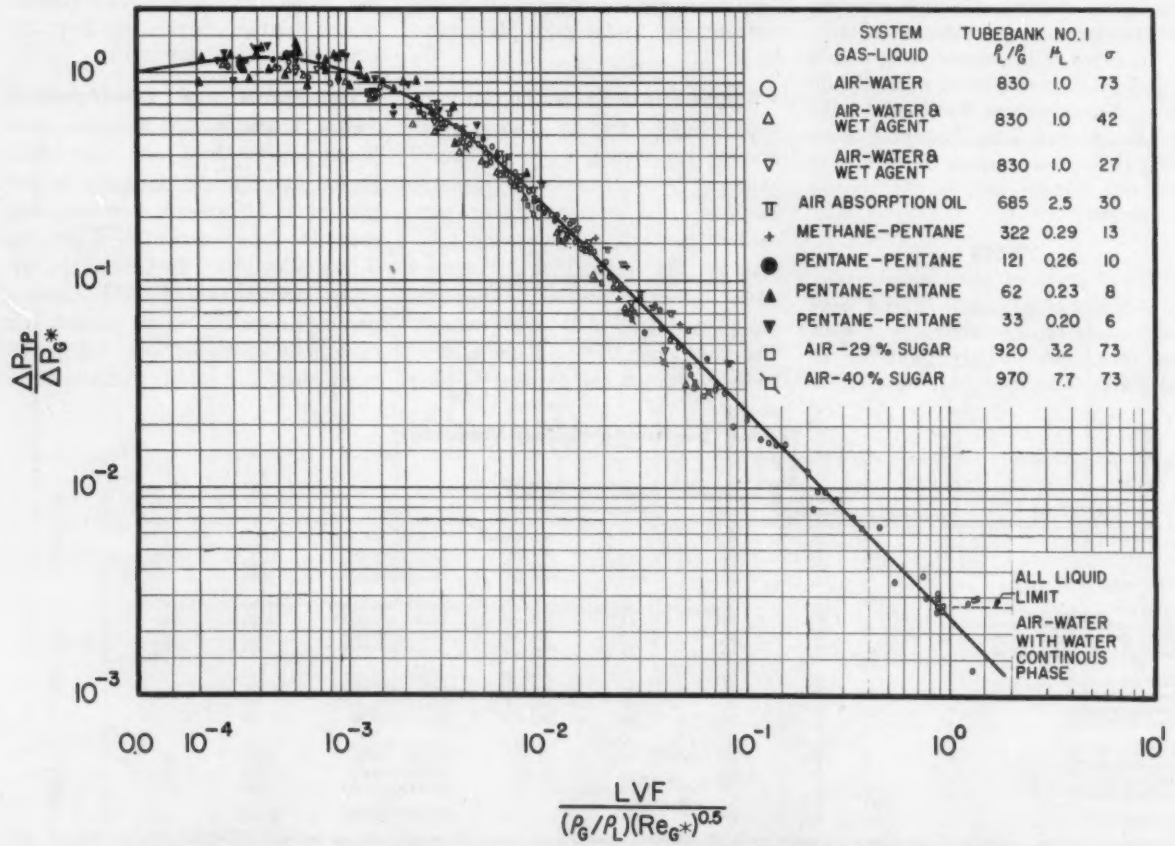

SYSTEM GAS-LIQUID
TUBEBANK NO. 1
AIR-WATER 830 1.0 73
AIR-WATER & WET AGENT 830 1.0 42
AIR-WATER & WET AGENT 830 1.0 27
AIR ABSORPTION OIL 685 2.5 30
METHANE-PENTANE 322 0.29 13
PENTANE-PENTANE 121 0.26 10
PENTANE-PENTANE 62 0.23 8
PENTANE-PENTANE 33 0.20 6
AIR-29 % SUGAR 920 3.2 73
AIR-40 % SUGAR 970 7.7 73
ALL LIQUID LIMIT
AIR-WATER WITH WATER CONTINOUS PHASE
$\frac{\Delta P_{TP}}{\Delta P_G^*}$
$\frac{LVF}{(\rho_G/\rho_L)(Re_{G^*})^{0.5}}$

FIGURE 6—Correlation of two-phase pressure drop for tubulent downflow through a bank of staggered tubes.

cally, the inshell test data follow the trend of the curves for flow in pipes. The atmospheric data show an average displacement of about minus 29 percent from the Lockhart and Martinelli curves. And the 90 psia data show an average displacement of about minus 42 percent. More significantly, the data scattered rather badly when correlated in this form. The data points show a deviation of plus or minus 100 percent from an average line through the data. To secure a more reliable basis for two-phase flow inshell, the development of a new correlation was undertaken.

Staggered Tubes. The air-water data at atmospheric pressure for the staggered-tube test section are correlated by plotting on logarithmic coordinates the ratio $\Delta P_{tp}/\Delta P_{G*}$ against $LVF/(Re_{G*})^{0.5}$. The pressure-drop ratio $\Delta P_{tp}/\Delta P_{G*}$ is the two-phase pressure drop divided by the all-gas pressure drop. The all-gas pressure drop is computed from the total mass flow of liquid and gas $(W_L + W_G)$, and the physical properties of the gas. LVF is the superficial liquid volume fraction of the mixture computed from the flow rates and densities of the two phases. The superficial LVF can differ from the actual LVF since the phases may travel at different velocities. The all-gas Reynolds number, Re_{G*}, is the fictitious single-phase Reynolds number based on the total mass flow and the physical properties of the gas.

With the preliminary correlation of the air-water data as a guide, the test program was broadened to cover liquids with different physical properties and to include tests at different pressure levels. The effect of pressure is defined by the introduction of the ratio of vapor to liquid densities as a parameter.

$$\Delta P_{tp}/\Delta P_{G*} = f\left[\frac{LVF}{\frac{\rho_G}{\rho_L}\left(Re_{G*}\right)^{0.5}}\right] \quad (1)$$

Figure 6 shows the final correlation of pressure drop for downflow of two-phase gas-liquid mixtures through horizontal tubebanks with staggered tubes. To plot the zero value of the abscissa on logarithmic coordinates, 1×10^{-4} is subtracted from the abscissa scale. This makes the low end of the scale converge such that zero appears at the normal position of 1×10^{-4}, 1×10^{-4} appears at the normal 2×10^{-4}, and 1×10^{-3} at the normal 1.1×10^{-3}. At abscissa values greater than 1×10^{-2} the significance of the subtraction disappears.

Figure 6 shows that over the range from 6 to 73 dynes/centimeter, liquid surface tension has no effect. This agrees with results reported for two-phase flow in pipes.[5]

Figure 6 also indicates that liquid viscosity, from about 0.2 to 3 centipoises, has no effect on the two-phase pressure drop. However, as the viscosity of the liquid increases, the data tend to fall on a curve of steeper slope, see Figure 7. The effect of liquid viscosity varies with the flow conditions, or the value of the abscissa. The solid curve taken from Figure 6 and the broken curve for systems with high liquid viscosity show a cross-over on Figure 7. To the right of the intersection the solid curve correlates systems with liquid viscosities from 0.2 to 3 centipoises, and the broken curve correlates liquid viscosities from about 8 to 50 centipoises. To the left, the solid curve correlates systems with

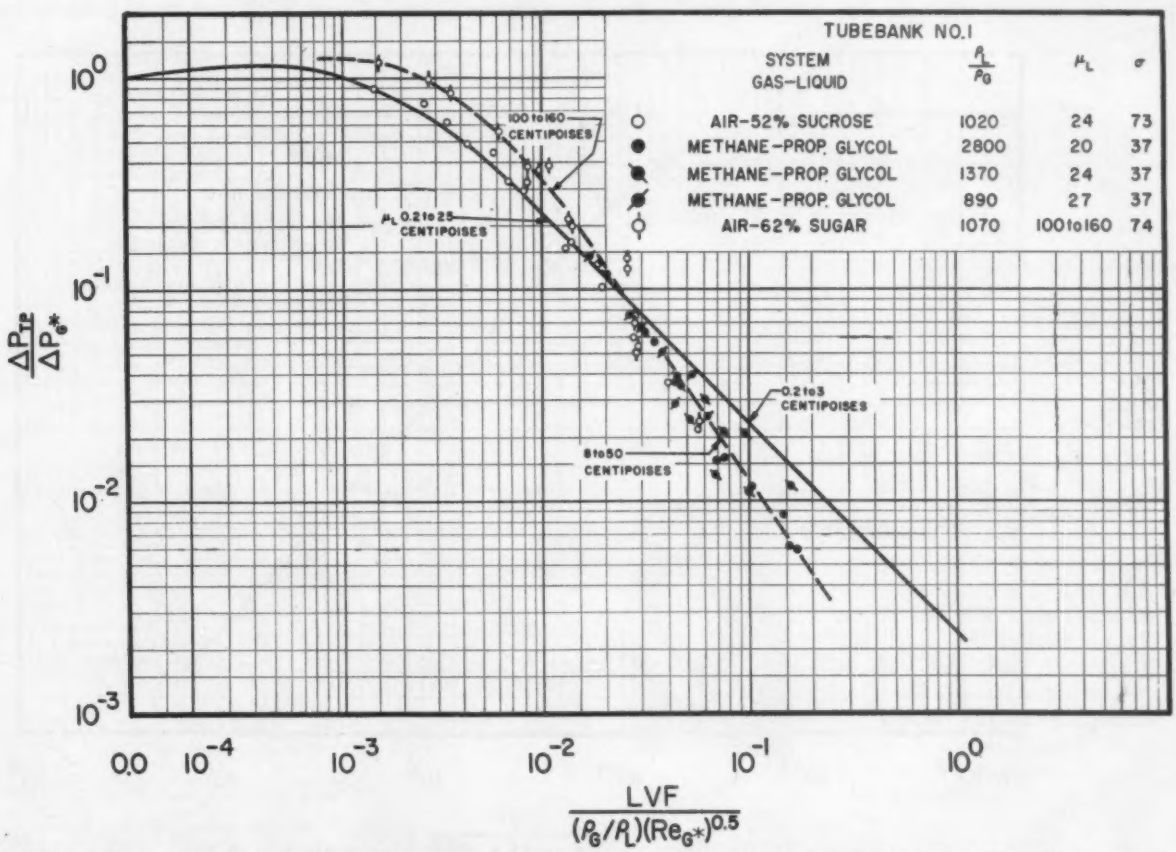


FIGURE 7—Effect of high liquid viscosity on two-phase pressure drop for downflow through a bank of staggered tubes. The solid curve is taken from Figure 6 and the broken curve is for systems of high liquid viscosity.

liquid viscosities from 0.2 to 25 centipoises and the broken curve correlates liquid viscosities from 100 to 160 centipoises.

Inline Tubes. Figure 8 shows the correlation of air-water test data at one atmosphere for the inline tubefield. The all-gas Reynolds number enters to the two-tenths power rather than the one-half power. Other than tube layout, the flow systems in the two tubebanks are identical. The other parameters are assumed to enter the correlations to the same power for staggered and inline banks.

Accuracy and Limitations. Figures 6 and 8 show that 90 percent of some 300 tests with systems having liquid viscosities equal to or less than 3 centipoises are correlated within a maximum deviation of plus or minus 20 percent. The average deviation of all the test points from the values predicted by the correlating curves is 10 percent.

The correlations apply to two-phase gas-liquid mixtures when the flow of the continuous phase or both phases is turbulent, Re_G or $Re_L \geq 5{,}000$. If both phases are in viscous flow, the correlation will predict values that are too high. When the flow is all gas and the abscissa equals zero, the correlation predicts a value of 1, for $\Delta P_{tp}/\Delta P_{G^*}$. This is the single phase gas pressure drop.

At the other end of the correlation, when the flow is all liquid

$$\Delta P_{tp}/\Delta P_{G^*} = \Delta P_L/\Delta P_{G^*} = (\rho_G/\rho_L)\ (\mu_L/\mu_G)^{0.1} \quad (2)$$

This all-liquid limit is shown in Figures 6 and 8 for the air water system where

$$(\rho_G/\rho_L)\ (\mu_L/\mu_G)^{0.1} = 0.0027 \quad (3)$$

The data points on Figure 6 which lie on the all liquid limit were obtained at LVF 0.99 with the bundle submerged in the water surge tank.

CONDENSATION PRESSURE DROP

The two-phase correlations developed in Figures 6 and 8 are based on tests with no change in the ratio of the phases. In a condenser, the ratio of gas to liquid continuously decreases as the vapor is condensed. And the pressure drop per unit length of travel decreases. Use of the correlations in computing pressure drop during condensation requires a summation of point values from inlet to outlet.

The pressure drop for 39 condensation tests with pentane in the pilot plant were computed and the results were compared with measured values in Figure 9. Two types of tests were made—partial condensation, and condensation with condensate recycle as described above. Predicted values agree with the test data with a maximum deviation of plus or minus 25 percent and an average deviation of 11 percent.

CONCLUSIONS

1. Gas-liquid two-phase pressure drops have been measured over a wide range of physical properties and flow conditions for downflow through two horizontal tubebanks. The tests were made in a staggered tubebank of ¾-inch tubes arranged on 45-degree 1-inch pitch and in an inline tube-

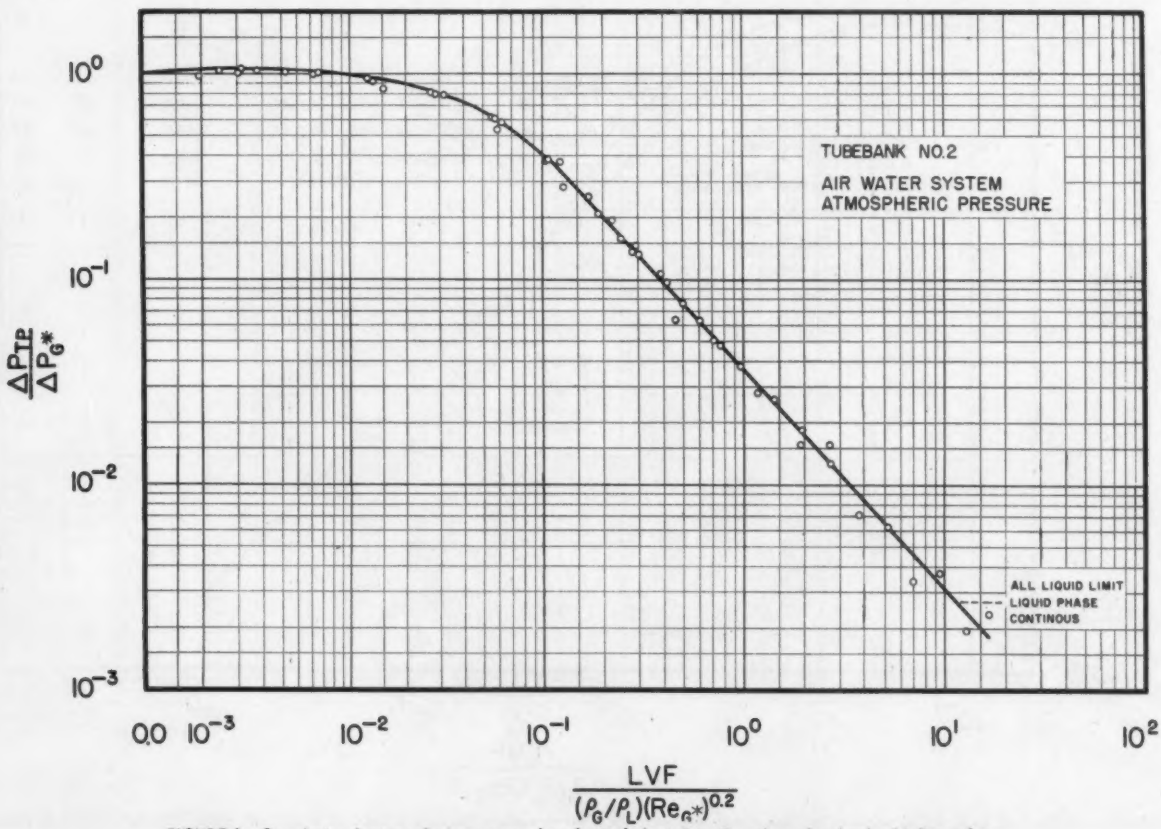


FIGURE 8—Correlation for two-phase pressure drop for turbulent downflow through a bank of inline tubes.

bank of ½-inch tubes arranged on 90-degree ⅝-inch pitch.

2. A preliminary evaluation of the inshell data was made using the method developed by Lockhart and Martinelli for two-phase flow in horizontal pipes. The scatter of the data was such that the development of a new correlation was undertaken.

3. The test data were used to develop new correlations for two-phase downflow in tubebanks. The correlations represent all of the data within a maximum deviation of plus or minus 35 percent, and 90 percent of the data within a maximum deviation of plus or minus 20 percent. The average deviation is 10 percent.

4. Condensation pressure drop can be predicted by a stepwise computation using the two-phase correlation. Condensation test data are predicted within a maximum deviation of plus or minus 25 percent. The average deviation is 11 percent.

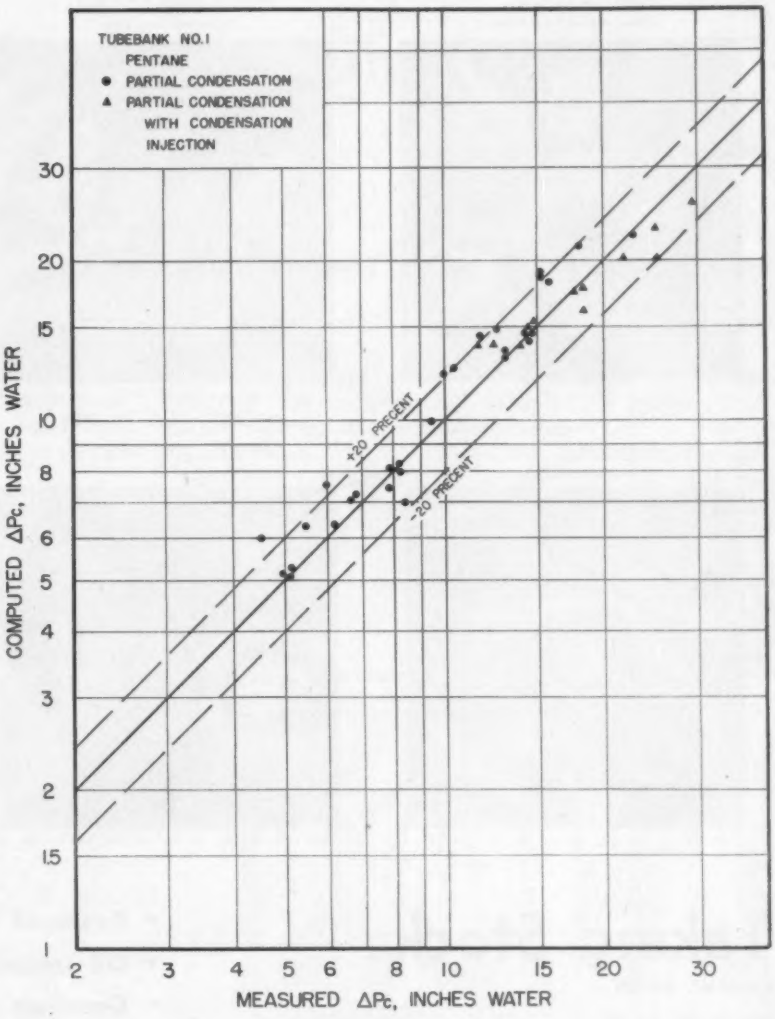


FIGURE 9—Tests of downflow condensation pressure-drop predictions with data for condensation on staggered tubes.

NOMENCLATURE

D = Tube outside diameter, ft
f = Friction factor, $f = \frac{2g\rho\Delta P}{4G^2N}$, dimensionless
g = Acceleration constant due to gravity, ft/sec²
G = Mass flow rate, lb/hr ft²
N = Number of restrictions encountered in flow through the tubebank
Re = Reynolds number, $Re = DG/\mu$, dimensionless
W = Flow rate of fluid, lb/hr
ΔP = Pressure-drop, lb/ft² or inches of water
μ = Viscosity, lb/ft hr
ρ = Density, lb/ft³
σ_L = Surface tension dynes/cm.
ϕ = The ratio $\Delta P_{tp}/\Delta P_{SP}$, dimensionless. Ordinate for the Lockhart and Martinelli correlation
X = The ratio $\Delta P_L/\Delta P_G$, dimensionless. Abscissa for the Lockhart and Martinelli correlation

SUBSCRIPTS

G = Gas phase
G* = Fictitious total flow as a gas
L = Liquid phase
SP = Single-phase
tp = Two-phase
tt = Turbulent liquid-turbulent gas flow, Lockhart and Martinelli
trt = Transition liquid-turbulent gas flow, Lockhart and Martinelli
vt = Turbulent liquid-viscous gas flow, Lockhart and Martinelli

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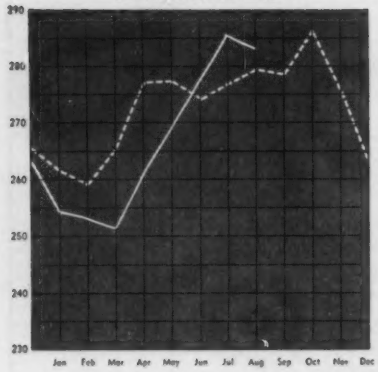
[5] Lockhart, R. W., and Martinelli, R. C. *Chem. Eng. Progress*, 45, 1949, 39-48.

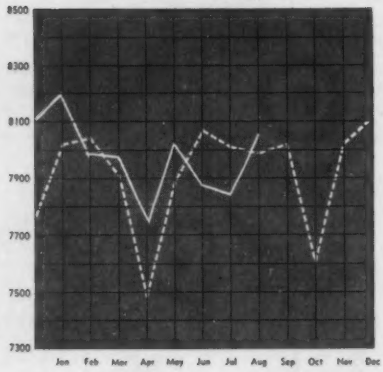
About the Author

JOHN E. DIEHL is a research engineer in the Heat Transfer group of the Research department for C F Braun & Co., Alhambra, Calif. He received his B.S. degree in 1944 and his M.S. degree in 1951, both from the University of Southern California. Diehl spent three years in the Navy, and prior to joining Braun, was with American Potash & Chemical Corp. He is a registered professional engineer in California.

CRUDE STOCKS
(Millions of Barrels End of Month)

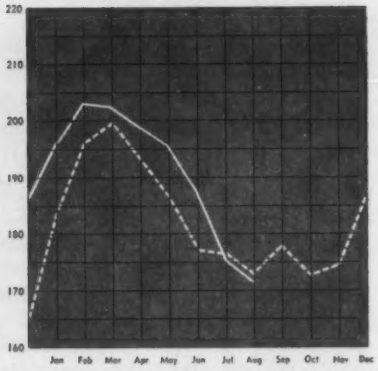


CRUDE RUNS TO STILLS
(Thousands of Barrels Daily)

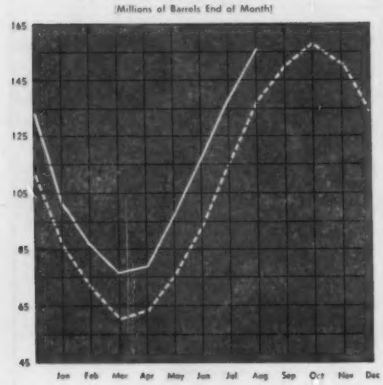


1956 1957

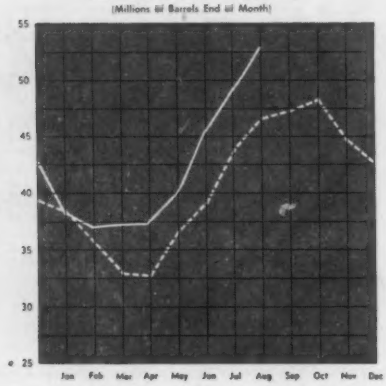
GASOLINE STOCKS
(Millions of Barrels End of Month)



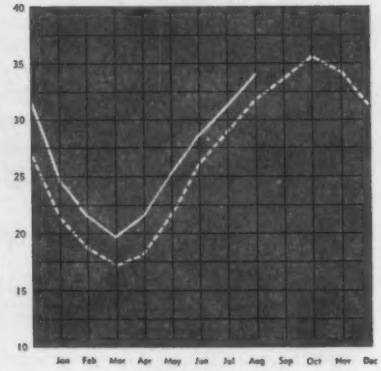
DISTILLATE FUEL STOCKS
(Millions of Barrels End of Month)



RESIDUAL FUEL STOCKS
(Millions of Barrels End of Month)



KEROSINE STOCKS
(Millions of Barrels End of Month)



Taking Stock

Cecil W. Smith
Economics Editor

- **Residual stocks highest since 1954**
- **Oil imports reach new high level**
- **Gasoline stocks continue to drop**

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1955:													
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3 784	150 194	279	36,361	1,621	143,248	1,061	46 267	829	1,218
October	6,837	7,465	267,346	3,827	153,103	309	36,705	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	341	33,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	342	17,215	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,209	299	18,227	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	292	21,883	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	290	26,111	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	296	28,990	1,767	115,787	1,066	43 958	1,084	1,463
August	7,195	7 995	279,944	4,037	172,939	313	31,826	1,839	137 905	1 091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	329	33,588	1,845	150 411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	356	35,667	1,772	158,871	1,082	48,400	1,004	1,541
November	7,139	8,031	275,995	3,913	174,808	384	34,329	1,841	151,517	1,182	44,590	871	1,362
December	7,377	8,141	266,014	4,039	187,271	379	31,420	1,981	133,981	1,288	44,491	873	1,471
1957:													
January	7,480	8,274	256,669	3,991	197,702	367	24,019	2,118	100,572	1,322	38,403	805	1,425
February	7,682	8,088	256,344	3,864	205,270	353	21,013	2,035	85,105	1,270	31,201	780	1,430
March	7,717	8,047	254,911	3,826	206,716	332	20,223	1,861	76,245	1,205	37 371	836	1,464
April	7,541	7,740	265,796	3,770	201,407	284	21,512	1,764	78,743	1,132	37,429	906	1,5·2
May	7,442	7,992	275,963	3,900	195,094	272	25,545	1,789	98,135	1,103	41,125	1,042	1,558
June	7,107	7,867	284,312	3,984	190,063	254	28,872	1,773	117,364	1,101	45.572	1,147	1,606
July	6,907	7,850	285,656	3,812	175,952	262	31,343	1,749	137,600	1,095	49,082	1,188	1,556
August	6,799	8,077	283,974	3,997	172,217	270	34,318	1,793	156,307	1,102	52,914	1,191	1,666
Week Ended:													
9-13-57	6,821	8,056	282,096	4,078	173,805	334	36,001	1,768	162,853	1,106	55,183	968	1,333
9-14-56	7,049	8,078	275,253	3,932	175,767	318	33,712	1,809	146,105	1,107	48,276	1,067	1,420

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

Thermo Data for Petrochemicals

Part XXII: The Chloroethanes

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Chemical Engineering Department
The University of Texas, Austin

The thermodynamic functions of many groups of compounds have been presented in previous papers in this series.[9, 10, 11] This article presents data for the chloroethanes.

CONSIDERABLE INTEREST has been shown recently in the determination of the thermodynamic functions of the chloroethanes. Original calculations have been made for the thermodynamic functions of 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane and hexachloroethane. The thermodynamic functions of the other members of the group have been collected and recalculated so that values are now available for the temperature range from 273.16 to 1500°K.

Original calculations for monochloroethane and 1,1-dichloroethane have been published by Daasch, Liang and Nielsen at the University of Oklahoma.[4] However, their data were only given at several points on the Kelvin scale. Therefore it was necessary to make original calculations to fill the gaps and extend the heat capacity data to 1500°K. The entropy, enthalpy function, and free energy function were then obtained by a process of numerical integration and interpolation.

Gwinn and Pitzer[6] have published the thermodynamic functions of 1,2-dichloroethane every 250° on the Kelvin scale. Their heat capacity data were recalculated and smoothed. The data were extended in the manner indicated previously.

Two good sources of thermodynamic data are available

* Dr. Harrison is now with Esso Research Laboratories, Baton Rouge, La.

TABLE 1
Heat Capacities of the Chloroethanes, °C.
cal./g-mole. °C.

°C.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
0	14.01	17.25	18.18	21.35	20.21	23.49	23.00	27.02	31.52
18	14.65	17.95	18.77	22.04	20.98	24.27	23.79	27.86	32.36
25	14.90	18.22	19.00	22.17	21.27	24.57	24.09	28.17	32.66
100	17.62	20.94	21.28	24.92	24.13	27.40	26.99	31.03	35.39
200	20.97	24.07	23.97	27.71	27.22	30.36	30.08	33.82	37.83
300	23.73	26.62	26.29	29.79	29.59	32.59	32.39	35.79	39.40
400	26.16	28.70	28.29	31.50	31.44	34.29	34.15	37.21	40.44
500	28.15	30.42	30.01	32.93	32.93	35.63	35.53	38.28	41.16
600	29.86	31.88	31.49	34.10	34.15	36.71	36.64	39.10	41.67
700	31.32	33.13	32.75	35.09	35.18	37.60	37.55	39.75	42.04
800	33.01	34.20	33.84	35.95	36.04	38.34	38.30	40.27	42.33
900	33.69	35.13	34.79	36.68	36.78	38.97	38.93	40.70	42.54
1000	34.64	35.93	35.62	37.30	37.42	39.49	39.47	41.06	42.71
1100	35.46	36.63	36.34	37.87	37.97	39.95	39.93	41.36	42.85
1200	36.17	37.24	36.97	38.36	38.45	40.33	40.32	41.61	42.96

TABLE 2
Heat Capacities of the Chloroethanes, °K.
cal./g-mole. °K.

°K.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
273.16	14.01	17.25	18.18	21.35	20.21	23.49	23.00	27.02	31.52
291.16	14.65	17.95	18.77	22.04	20.98	24.27	23.79	27.86	32.36
298.16	14.90	18.22	19.00	22.33	21.27	24.57	24.09	28.17	32.66
300	14.97	18.27	19.06	22.40	21.34	24.63	24.16	28.24	32.74
400	18.56	21.84	22.04	25.74	25.03	28.28	27.90	31.88	36.16
500	21.78	24.81	24.63	28.32	27.92	31.02	30.77	34.42	38.32
600	24.48	27.22	26.86	30.27	30.13	33.09	32.91	36.22	39.72
700	26.73	29.19	28.78	31.92	31.87	34.68	34.55	37.53	40.65
800	28.64	30.84	30.43	33.26	33.28	35.94	35.85	38.52	41.31
900	30.27	32.24	31.85	34.38	34.44	36.97	36.90	39.29	41.78
1000	31.68	33.43	33.06	35.33	35.42	37.81	37.76	39.90	42.13
1100	32.90	34.46	34.11	36.16	36.25	38.52	38.48	40.39	42.39
1200	33.95	35.36	35.02	36.86	36.97	39.12	39.09	40.81	42.59
1300	34.87	36.13	35.82	37.47	37.58	39.62	39.60	41.15	42.75
1400	35.66	36.80	36.52	38.01	38.11	40.06	40.04	41.43	42.88
1500	36.35	37.38	37.12	38.47	38.56	40.43	40.41	41.68	42.98

TABLE 3
Heat Capacities of the Chloroethanes, °F.
Btu./lb.-mole. °F.

°F.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
32	14.01	17.25	18.18	21.35	20.21	23.49	23.00	27.02	31.52
60	14.56	17.86	18.69	21.95	20.88	24.17	23.68	27.75	32.25
77	14.90	18.22	19.00	22.33	21.27	24.57	24.09	28.17	32.66
100	15.37	18.69	19.41	22.80	21.79	25.09	24.61	28.70	33.19
200	17.38	20.70	21.08	24.70	23.89	27.17	26.75	30.80	35.18
300	19.31	22.54	22.64	26.37	25.73	28.95	28.61	32.52	36.72
400	21.10	24.19	24.08	27.80	27.34	30.47	30.19	33.92	37.91
500	22.74	25.67	25.41	29.03	28.72	31.78	31.55	35.08	38.85
600	24.20	26.97	26.63	30.07	29.91	32.89	32.70	36.04	39.59
700	25.53	28.14	27.75	31.03	30.95	33.85	33.69	36.85	40.18
800	26.72	29.18	28.78	31.92	31.87	34.68	34.55	37.53	40.65
900	27.82	30.13	29.72	32.70	32.68	35.41	35.31	38.11	41.05
1000	28.83	31.00	30.60	33.39	33.42	36.06	35.98	38.61	41.37
1100	29.75	31.79	31.40	34.03	34.07	36.65	36.57	39.05	41.64
1200	30.60	32.52	32.13	34.60	34.67	37.17	37.11	39.43	41.86
1300	31.38	33.18	32.81	35.13	35.22	37.63	37.58	39.77	42.06
1400	32.11	33.79	33.43	35.62	35.72	38.06	38.02	40.08	42.22
1500	32.77	34.35	34.00	36.07	36.17	38.45	38.41	40.34	42.36
1600	33.39	34.87	34.53	36.48	36.58	38.80	38.76	40.59	42.48
1700	33.95	35.36	35.02	36.86	36.96	39.12	39.08	40.81	42.59
1800	34.48	35.80	35.48	37.21	37.32	39.41	39.38	41.00	42.69
1900	34.96	36.21	35.90	37.53	37.64	39.67	39.65	41.18	42.77
2000	35.41	36.59	36.30	37.84	37.94	39.92	39.90	41.34	42.84
2100	35.82	36.94	36.66	38.12	38.21	40.14	40.13	41.49	42.90
2200	36.20	37.26	36.99	38.38	38.47	40.35	40.33	41.62	42.96

TABLE 4
Heat Capacities of the Chloroethanes, °R.
Btu./lb.-mole. °R.

°R.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
491.69	14.01	17.25	18.18	21.35	20.21	23.49	23.00	27.02	31.52
500	14.17	17.43	18.33	21.53	20.41	23.69	23.20	27.24	31.74
519.69	14.56	17.86	18.69	21.95	20.88	24.17	23.68	27.75	32.25
536.69	14.90	18.22	19.00	22.33	21.27	24.57	24.09	28.17	32.66
600	16.18	19.52	20.09	23.59	22.66	25.96	25.50	29.60	34.05
700	18.17	21.47	21.72	25.41	24.66	27.92	27.53	31.54	35.85
800	20.05	23.23	23.23	26.97	26.41	29.60	29.28	33.12	37.24
900	21.78	24.81	24.63	28.32	27.92	31.02	30.76	34.42	38.32
1000	23.35	26.21	25.91	29.47	29.22	32.25	32.03	35.49	39.17
1100	24.75	27.46	27.09	30.43	30.35	33.29	33.11	36.38	39.84
1200	26.02	28.57	28.18	31.40	31.33	34.19	34.05	37.13	40.38
1300	27.18	29.58	29.17	32.25	32.21	34.98	34.87	37.77	40.82
1400	28.24	30.49	30.08	32.99	32.99	35.68	35.59	38.32	41.18
1500	29.21	31.33	30.93	33.65	33.69	36.31	36.23	38.79	41.48
1600	30.10	32.09	31.70	34.27	34.32	36.86	36.79	39.21	41.73
1700	30.92	32.79	32.41	34.82	34.90	37.36	37.30	39.58	41.94
1800	31.68	33.43	33.07	35.33	35.42	37.81	37.76	39.90	42.13
1900	32.38	34.02	33.67	35.81	35.90	38.22	38.18	40.19	42.28
2000	33.02	34.57	34.22	36.24	36.34	38.59	38.55	40.44	42.41
2100	33.62	35.07	34.73	36.64	36.74	38.93	38.89	40.68	42.53
2200	34.17	35.54	35.21	37.00	37.11	39.24	39.21	40.89	42.63
2300	34.68	35.97	36.65	37.34	37.45	39.52	39.49	41.08	42.72
2400	35.15	36.36	36.06	37.66	37.76	39.77	39.75	41.25	42.80
2500	35.58	36.73	36.45	37.96	38.05	40.01	39.99	41.40	42.87
2600	35.98	37.07	36.80	38.23	38.32	40.23	40.21	41.54	42.93
2700	36.35	37.38	37.12	38.47	38.56	40.35	40.33	41.62	42.98

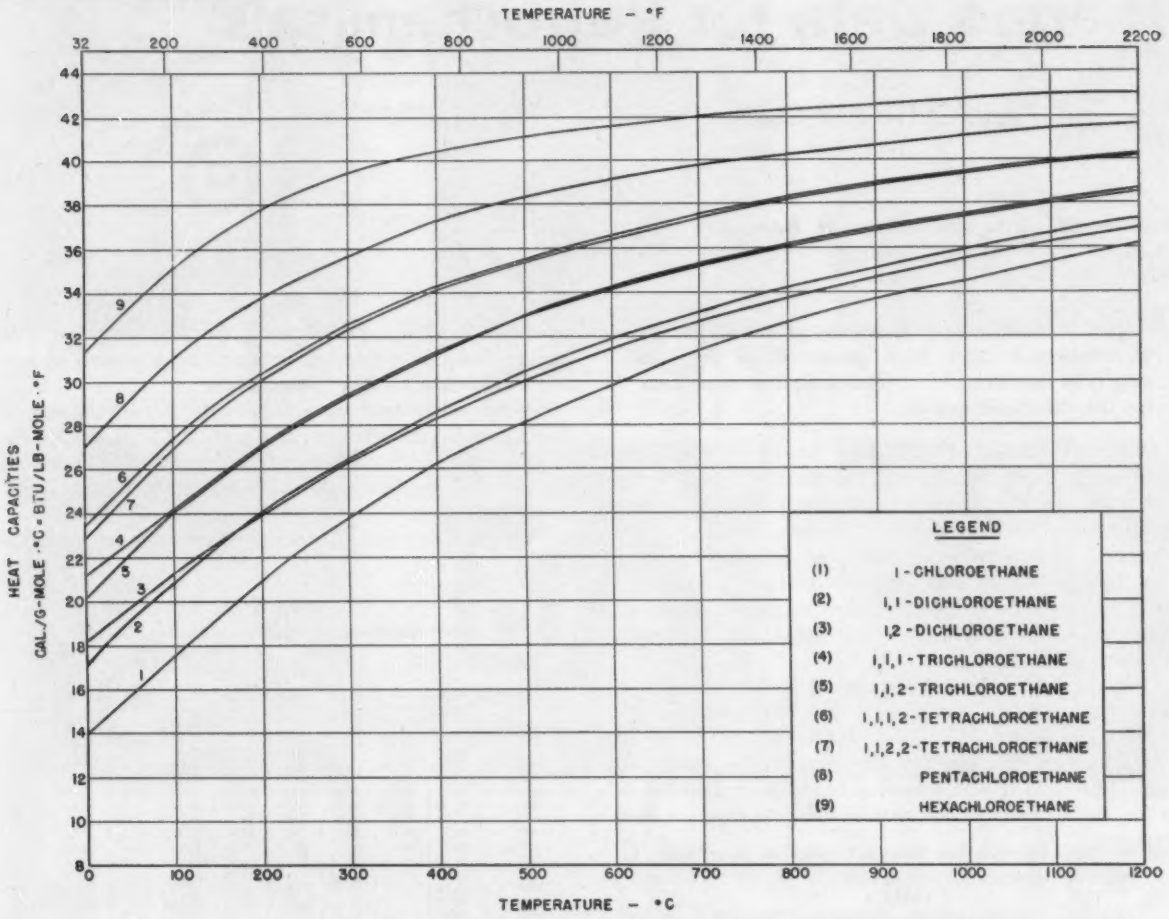
TEMPERATURE – °F
32 200 400 600 800 1000 1200 1400 1600 1800 2000 2200
44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8
HEAT CAPACITIES
CAL./G-MOLE · °C · BTU/LB-MOLE · °F
9 8 6 7 4 5 3 2 1
LEGEND
(1) 1-CHLOROETHANE
(2) 1,1-DICHLOROETHANE
(3) 1,2-DICHLOROETHANE
(4) 1,1,1-TRICHLOROETHANE
(5) 1,1,2-TRICHLOROETHANE
(6) 1,1,1,2-TETRACHLOROETHANE
(7) 1,1,2,2-TETRACHLOROETHANE
(8) PENTACHLOROETHANE
(9) HEXACHLOROETHANE
0 100 200 300 400 500 600 700 800 900 1000 1100 1200
TEMPERATURE – °C

FIGURE 1—Molar heat capacities of the chloroethanes

for 1,1,1-trichloroethane. El-Sabban, Meister and Cleveland[5] have published the thermodynamic functions over a wide temperature range. They assigned their frequencies on the basis of a normal coordinate treatment. Pitzer and Hollenberg in a later article[13] have also published the thermodynamic functions over a wide temperature range. They measured the infra-red spectrum from 130 to 430 cm^{-1} with a grating spectrometer. Their assignment of frequencies yields approximately the same thermodynamic values as those published by El-Sabban *et al.* The data presented here are those of Pitzer and Hollenberg, and have been interpolated to the other temperature scales.

The thermodynamic functions of 1,1,2-trichloroethane were calculated from spectroscopic data and compared to experimental heat capacities measured by Harrison.[7,8]

Like two previous compounds, the thermodynamic functions of 1,1,1,2-tetrachloroethane and pentachloroethane were also determined by Nielsen, Liang and Daasch.[12] Again it was necessary to fill the gaps and extend the data to 1500°K. The entropy of pentachloroethane at 500°K. was corrected.

Since no data on the thermodynamic functions of

TABLE 5
Enthalpies of the Chloroethanes, °C.
cal./g-mole = Pcu./lb.-mole

°C.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2,-	penta-	hexa-
0	0	0	0	0	0	0	0	0	0
18	256	316	330	391	371	430	421	495	576
25	359	442	462	545	519	601	588	691	803
100	1579	1912	1971	2326	2224	2553	2507	2915	3360
200	3514	4170	4238	4964	4798	5448	5367	6165	7030
300	5758	6708	6754	7839	7644	8601	8496	9652	10900
400	8260	9477	9485	10910	10700	11950	11830	13310	14890
500	10980	12430	12400	14140	13920	15450	15310	17080	18970
600	13880	15550	15480	17490	17270	19070	18920	20950	23120
700	16940	18800	18690	20950	20740	22780	22640	24900	27300
800	20140	22170	22020	24500	24300	26580	26430	28900	31520
900	23450	25640	25460	28130	27950	30450	30230	32950	35760
1000	26870	29190	28980	31830	31660	34370	34210	37040	40030
1100	30380	32820	32580	35600	35430	38340	38180	41160	44310
1200	33960	36520	36240	39110	39250	42360	42190	45310	48600

TABLE 6
Enthalpies of the Chloroethanes, °K.
cal./g-mole = Pcu./lb.-mole

°K.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
237.16	0	0	0	0	0	0	0	0	0
291.16	256	316	330	391	371	430	421	495	576
298.16	359	442	462	545	519	601	588	691	803
300	389	477	495	587	558	646	633	742	862
400	2066	2487	2553	3007	2884	3300	3244	3759	4320
500	4088	4826	4890	5714	5538	6272	6184	7081	8052
600	6406	7430	7467	8645	8445	9482	9373	10620	11960
700	8970	10250	10250	11760	11550	12870	12750	14310	15980
800	11740	13260	13210	15020	14810	16410	16270	18110	20080
900	14690	16410	16330	18410	18200	20050	19910	22010	24240
1000	17790	19700	19580	21890	21690	23790	23650	25970	28430
1100	21020	23090	22940	25470	25280	27610	27480	29980	32660
1200	24360	26580	26390	29120	28940	31490	31340	34040	36910
1300	27800	30160	29940	32840	32660	35430	35270	38140	41170
1400	31330	33810	33550	36610	36450	39420	39260	42270	45460
1500	34930	37520	37240	40440	40280	43440	43280	46430	49750

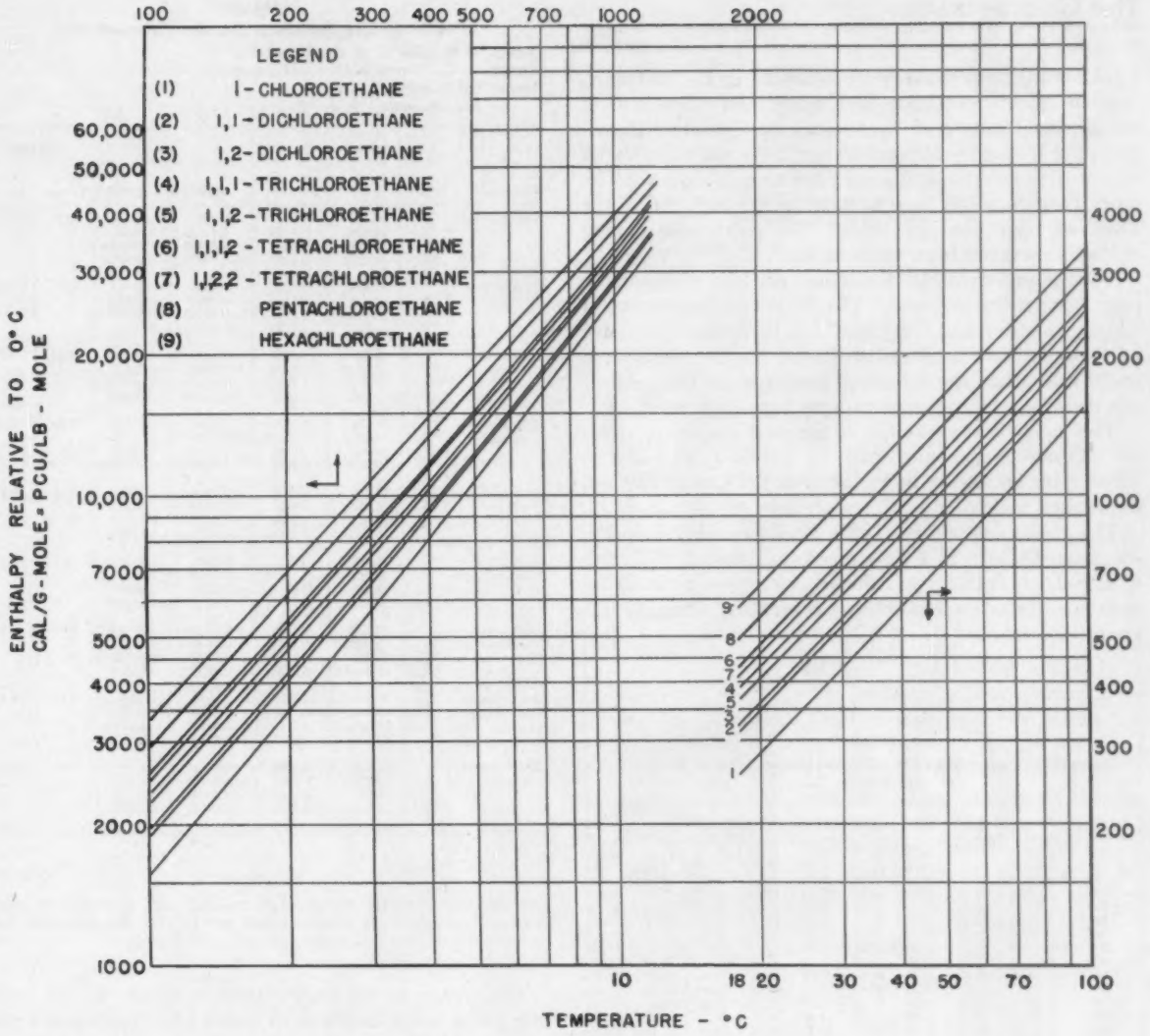

FIGURE 2—Molar enthalpies of the chlorethanes.

TABLE 7
Enthalpies of the Chloroethanes, °F.
Btu./lb.-mole

°F.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
32	0	0	0	0	0	0	0	0	0
60	398	491	514	609	576	669	655	770	897
77	646	795	835	981	934	1081	1058	1243	1446
100	997	1221	1269	1503	1429	1652	1619	1896	2202
200	2634	3192	3294	3888	3713	4267	4188	4875	5625
300	4469	5356	5481	6447	6198	7076	6960	8044	9222
400	6491	7694	7818	9156	8854	10050	9902	11370	12960
500	8684	10190	10290	11990	11660	13160	12990	14820	16800
600	11030	12820	12900	14950	14590	16400	16200	18380	20720
700	13520	15580	15620	18010	17640	19740	19530	22020	24710
800	16130	18450	18440	21160	20780	23160	22940	25740	28750
900	18860	21410	21370	24390	24010	26670	26430	29530	32840
1000	21690	24470	24390	27700	27310	30240	30000	33360	36960
1100	24620	27610	27490	31070	30690	33880	33630	37240	41110
1200	27640	30830	30660	34500	34120	37570	37310	41170	45280
1300	30740	34110	33910	37990	37620	41310	41040	45130	49480
1400	33920	37460	37220	41530	41170	45090	44830	49120	53700
1500	37160	40870	40600	45110	44760	48920	48650	53140	57930
1600	40470	44330	44020	48740	48400	52780	52500	57190	62170
1700	43840	47840	47500	52410	52080	56680	56400	61260	66420
1800	47260	51400	51030	56110	55790	60600	60320	65350	70680
1900	50730	55000	54600	59850	59540	64560	64270	69460	74960
2000	54250	58640	58210	63620	63320	68540	68250	73590	79240
2100	57810	62320	61860	67410	67120	72540	72250	77730	83520
2200	61410	66030	65540	71240	70960	76570	76270	81880	87820

TABLE 8
Enthalpies of the Chloroethanes, °R.
Btu./lb.-mole

°R.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
491.69	0	0	0	0	0	0	0	0	0
500	116	143	150	178	169	195	193	225	262
519.69	398	491	514	609	576	669	655	770	897
537.69	646	795	831	981	934	1081	1058	1243	1446
600	1633	1991	2065	2442	2323	2681	2626	3071	3558
700	3351	4042	4157	4900	4694	5378	5280	6131	7056
800	5263	6278	6405	7522	7250	8255	8128	9367	10710
900	7355	8681	8799	10290	9964	11290	11130	12750	14490
1000	9613	11230	11330	13170	12830	14450	14270	16240	18370
1100	12020	13920	13980	16170	15810	17730	17530	19840	22320
1200	14560	16720	16740	19270	18890	21110	20880	23510	26330
1300	17220	19630	19610	22460	22060	24570	24330	27260	30390
1400	19990	22630	22570	25720	25330	28100	27860	31070	34490
1500	22860	25730	25630	29050	28660	31700	31450	34920	38630
1600	25830	28900	28760	32450	32060	35360	35100	38820	42790
1700	28880	32140	31970	35900	35530	39070	38800	42760	46970
1800	32010	35450	35240	39410	39040	42830	42560	46740	51180
1900	35220	38830	38580	42970	42610	46630	46360	50740	55400
2000	38490	42260	41970	46570	46220	50470	50190	54770	59630
2100	41820	45740	45420	50210	49880	54350	54070	58830	63880
2200	45210	49270	48920	53890	53570	58260	57980	62910	68140
2300	48650	52840	52460	57610	57300	62190	61910	67000	72400
2400	52140	56460	56050	61360	61060	66160	65870	71120	76680
2500	55680	60120	59670	65140	64850	70150	69860	75250	80960
2600	59260	63810	63340	68950	68660	74160	73880	79400	85250
2700	61410	66030	67030	72790	72510	76570	77900	81880	89550

1,1,2,2-tetrachloroethane were available in the literature, original calculations have been made.[7] Dr. Cleveland of the Illinois Institute of Technology has furnished the vibrational frequency assignment for the trans form for all except the torsional oscillation prior to publication.[15] The latter frequency has been assumed as 90 cm^{-1}. All of the functions have been calculated. The entropy of mixing of the isomers has been taken as Rln3.

The thermodynamic functions of hexachloroethane have been calculated also.[7] The frequency assignment of Carney, Meister and Cleveland[2] has been made available by Daasch.[8] The torsional oscillation has been estimated as 70 cm^{-1} since the barrier is known to be high. All of the thermodynamic functions have been calculated.

The molar heat capacities of the ideal gas are reported for all four temperature scales in Tables 1, 2, 3 and 4. These data are shown in Figure 1 on the Centigrade and Fahrenheit scales.

The molar enthalpies of the ideal gas relative to the ice point, O C. = 32 F., are given in Tables 5, 6, 7, and 8. The molar enthalpy in calories/gram mole, or Pcu./lb.-mole are shown in Figure 2 as a function of the Centigrade temperature.

TABLE 9
Mean Heat Capacities of the Chloroethanes From 0°C. to t°C.
cal./g-mole. °C.

°C.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
0	14.01	17.25	18.18	21.35	20.21	23.49	23.00	27.02	31.52
18	14.23	17.53	18.33	21.75	20.62	23.88	23.38	27.48	31.98
25	14.36	17.67	18.48	21.80	20.76	24.03	23.51	27.63	32.13
100	15.79	19.12	19.71	23.26	22.24	25.53	25.07	29.15	33.60
200	17.57	20.85	21.19	24.82	23.99	27.24	26.84	30.82	35.15
300	19.19	22.36	22.51	26.13	25.48	28.67	28.32	32.17	36.32
400	20.65	23.69	23.71	27.27	26.75	29.87	29.57	33.27	37.23
500	21.96	24.87	24.80	28.27	27.84	30.89	30.63	34.17	37.95
600	23.14	25.92	25.80	29.15	28.79	31.79	31.54	34.92	38.53
700	24.20	26.86	26.70	29.93	29.63	32.55	32.34	35.57	39.00
800	25.17	27.71	27.53	30.63	30.38	33.23	33.04	36.12	39.40
900	26.06	28.49	28.28	31.26	31.05	33.83	33.59	36.61	39.74
1000	26.87	29.19	28.98	31.83	31.66	34.37	34.21	37.04	40.03
1100	27.62	29.84	29.61	32.36	32.21	34.86	34.71	37.42	40.28
1200	28.30	30.43	30.20	32.84	32.71	35.30	35.16	37.76	40.50

TABLE 10
Mean Heat Capacities of the Chloroethanes From 32° F. to t°F.
Btu./lb.-mole. °F.

°F.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
32	14.01	17.25	18.18	21.35	20.21	23.49	23.00	27.02	31.52
60	14.22	17.53	18.36	21.75	20.57	23.88	23.40	27.50	32.02
77	14.36	17.67	18.48	21.80	20.76	24.03	23.51	27.63	32.13
100	14.66	17.96	18.66	22.10	21.01	24.30	23.81	27.89	32.38
200	15.68	19.00	19.61	23.14	22.10	25.40	24.93	29.02	33.48
300	16.68	19.98	20.45	24.06	23.13	26.40	25.97	30.01	34.41
400	17.64	20.91	21.24	24.88	24.06	27.31	26.91	30.89	35.21
500	18.56	21.77	21.99	25.63	24.91	28.13	27.76	31.67	35.89
600	19.42	22.57	22.70	26.32	25.69	28.87	28.53	32.35	36.48
700	20.24	23.32	23.38	26.96	26.40	29.54	29.23	32.97	36.99
800	21.01	24.02	24.02	27.55	27.05	30.16	29.87	33.52	37.44
900	21.73	24.67	24.62	28.10	27.66	30.72	30.45	34.02	37.83
1000	22.41	25.28	25.19	28.61	28.21	31.24	30.99	34.46	38.18
1100	23.06	25.85	25.74	29.09	28.73	31.72	31.48	34.87	38.49
1200	23.67	26.39	26.25	29.54	29.22	32.16	31.94	35.25	38.77
1300	24.24	26.90	26.74	29.96	29.67	32.58	32.37	35.59	39.02
1400	24.79	27.38	27.21	30.36	30.09	32.96	32.77	35.91	39.25
1500	25.31	27.84	27.65	30.73	30.49	33.32	33.14	36.20	39.46
1600	25.81	28.27	28.08	31.08	30.87	33.66	33.48	36.47	39.65
1700	26.28	28.68	28.48	31.42	31.22	33.98	33.81	36.73	39.82
1800	26.73	29.07	28.86	31.74	31.56	34.28	34.12	36.96	39.98
1900	27.16	29.44	29.23	32.04	31.87	34.56	34.41	37.18	40.13
2000	27.57	29.80	29.58	32.33	32.17	34.83	34.68	37.39	40.26
2100	27.95	30.13	29.91	32.60	32.46	35.08	34.94	37.59	40.39
2200	28.33	30.45	30.23	32.86	32.73	35.32	35.18	37.77	40.51

TABLE 11
Heat Capacity Equations for the Chloroethanes
Range: 0 to 1200°C. or equivalent
Equation: $C_p° = a + b(t) + c(t^2) + d(t^3)$
Units: cal./g-mole. °C. or °K.
Btu./lb.-mole. °F. or °R.

Compound	T	a	b.10^2	c.10^5	d.10^8	ERROR Max. Percent	ERROR Avg. Percent
1-chloroethane	°C.	14.110	3.7537	−2.0813	0.39844	0.74	0.46
	°K.	2.2222	4.9799	−2.4078	0.39844		
	°F.	13.436	2.1267	−0.64893	0.068320		
	°R.	2.2222	2.7666	−0.74315	0.068320		
1,1-dichloro-ethane	°C.	17.250	3.8971	−2.9500	0.90885	0.54	0.22
	°K.	4.2183	5.7122	−3.6948	0.90885		
	°F.	16.548	2.2237	−0.92549	0.15584		
	°R.	4.2183	3.1734	−1.1404	0.15584		
1,2-dichloro-ethane	°C.	18.180	3.2758	−2.0938	0.55729	0.33	0.07
	°K.	7.5559	4.5444	−2.5505	0.55729		
	°F.	17.591	1.8616	−0.65541	0.095557		
	°R.	7.5559	2.5247	−0.78719	0.095557		
1,1,1-trichloro-ethane	°C.	21.500	3.5237	−2.9094	0.95313	0.90	0.36
	°K.	9.5095	5.3265	−3.6905	0.95313		
	°F.	20.865	2.0156	−0.91362	0.16343		
	°R.	9.5095	2.9592	−1.1390	0.16343		
1,1,2-trichloro-ethane	°C.	20.330	3.9908	−3.4516	1.1552	0.68	0.37
	°K.	6.6178	6.1351	−4.3983	1.1552		
	°F.	19.610	2.2859	−1.0843	0.19808		
	°R.	6.6178	3.4084	−1.3575	0.19808		
1,1,1,2-tetra-chloroethane	°C.	23.640	3.9117	−3.5906	1.2474	0.76	0.39
	°K.	10.021	6.1525	−4.6128	1.2474		
	°F.	22.933	2.2448	−1.1287	0.21389		
	°R.	10.021	3.4181	−1.4237	0.21389		
1,1,2,2-tetra-chloroethane	°C.	23.150	4.0379	−3.7094	1.2865	0.80	0.36
	°K.	9.0900	6.3524	−4.7637	1.2865		
	°F.	22.420	2.3172	−1.1661	0.22059		
	°R.	9.0900	3.5291	−1.4703	0.22059		
Pentachloro-ethane	°C.	27.260	3.8629	−3.9563	1.4505	0.93	0.49
	°K.	13.460	6.3490	−5.1450	1.4505		
	°F.	26.560	2.2249	−1.2450	0.24871		
	°R.	13.460	3.5272	−1.5880	0.24871		
Hexachloro-ethane	°C.	31.820	3.6396	−4.2031	1.6198	0.95	0.56
	°K.	18.412	6.2984	−5.5305	1.6198		
	°F.	31.160	2.1059	−1.3239	0.27774		
	°R.	18.412	3.4991	−1.7069	0.27774		

The mean molar heat capacities above the ice point are given in Tables 9 and 10 on the Centigrade and Fahrenheit scales.

Cubic equations representing the heat capacities of the compounds in all four temperature scales are given in Table 11.

TABLE 12
Enthalpy Functions of the Chloroethanes, $(H° - H°_0)/T$
cal./g-mole. °K.

°K.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
273.16	10.19	11.84	13.33	14.06	13.74	15.69	15.68	17.84	20.84
298.16	10.54	12.33	13.76	14.71	14.33	16.38	16.34	18.66	21.78
300	10.57	12.37	13.79	14.76	14.37	16.44	16.39	18.72	21.85
400	12.12	14.30	15.49	17.12	16.60	18.96	18.82	21.58	25.03
500	13.74	16.12	17.07	19.11	18.58	21.11	20.94	23.91	27.49
600	15.31	17.77	18.51	20.81	20.33	22.95	22.76	25.82	29.42
700	16.79	19.27	19.85	22.29	21.86	24.51	24.33	27.41	30.96
800	18.15	20.61	21.07	23.58	23.20	25.87	25.70	28.73	32.22
900	19.41	21.83	22.19	24.72	24.39	27.04	26.88	29.87	33.25
1000	20.57	22.93	23.22	25.73	25.44	28.08	27.93	30.84	34.12
1100	21.64	23.93	24.16	26.65	26.39	29.00	28.86	31.69	34.86
1200	22.62	24.85	25.03	27.47	27.24	29.82	29.69	32.43	35.50
1300	23.53	25.69	25.83	28.21	28.02	30.55	30.43	33.09	36.05
1400	24.37	26.46	26.57	28.90	28.72	31.22	31.10	33.67	36.54
1500	25.14	27.17	27.25	29.52	29.36	31.82	31.71	34.20	36.96

TABLE 13

Entropies of the Chloroethanes, S° cal./g-mole. °K.

°K.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
273.16	64.42	71.19	72.22	75.18	78.76	83.00	84.63	88.53	91.97
298.16	65.68	72.74	73.81	77.09	80.57	85.10	86.69	90.94	94.77
300	65.78	72.86	73.92	77.22	80.71	85.26	86.84	91.12	94.98
400	70.57	78.62	79.83	84.15	87.37	92.87	94.33	99.77	104.91
500	75.07	83.81	85.10	90.17	93.28	99.49	100.88	107.18	113.23
600	79.29	88.52	89.83	95.53	98.58	105.34	106.69	113.62	120.34
700	83.24	92.87	94.11	100.34	103.36	110.57	111.89	119.31	126.54
800	86.93	96.88	98.01	104.67	107.71	115.28	116.59	124.39	132.02
900	90.40	100.60	101.62	108.66	111.70	119.58	120.88	128.97	136.91
1000	93.67	104.06	105.00	112.34	115.38	123.52	124.81	133.14	141.33
1100	96.74	107.29	108.21	115.74	118.80	127.15	128.45	136.97	145.36
1200	99.65	110.33	111.29	118.92	121.98	130.53	131.82	140.50	149.06
1300	102.41	113.19	114.09	121.90	124.96	133.68	134.97	143.78	152.47
1400	105.02	115.89	116.77	124.68	127.77	136.64	137.92	146.84	155.64
1500	107.50	118.45	119.31	127.33	130.41	139.41	140.69	149.71	158.61

TABLE 14

Free Energy Functions of the Chloroethanes,-(G°-H₀°)/T cal./g-mole. °K.

°K.	1-	1,1-	1,2-	1,1,1-	1,1,2-	1,1,1,2-	1,1,2,2-	penta-	hexa-
273.16	54.23	59.35	58.89	61.11	65.02	67.32	68.95	70.69	71.13
298.16	55.14	60.41	60.05	62.37	66.24	68.72	70.35	72.28	72.99
300	55.21	60.49	60.13	62.45	66.33	68.82	70.45	72.40	73.13
400	58.45	64.31	64.34	67.04	70.78	73.91	75.51	78.19	79.88
500	61.33	67.70	67.94	71.05	74.70	78.38	79.94	83.27	85.74
600	63.97	70.75	71.32	74.58	78.25	82.39	83.93	87.80	90.93
700	66.45	73.60	74.26	78.03	81.50	86.05	87.56	91.90	95.58
800	68.78	76.27	76.94	81.09	84.51	89.42	90.90	95.65	99.80
900	70.99	78.77	79.43	83.94	87.31	92.53	94.00	99.10	103.66
1000	73.10	81.13	81.78	86.61	89.94	95.44	96.88	102.30	107.21
1100	75.11	83.36	84.05	89.09	92.41	98.16	99.59	105.28	110.49
1200	77.03	85.48	86.26	91.44	94.74	100.72	102.14	108.07	113.56
1300	78.88	87.50	88.26	93.68	96.95	103.13	104.54	110.69	116.42
1400	80.65	89.44	90.20	95.79	99.05	105.42	106.82	113.17	119.11
1500	82.36	91.29	92.06	97.80	101.05	107.60	108.98	115.51	121.65

TABLE 15

Heats of Formation, Free Energies of Formation, Heats of Vaporization, and Molecular Weights of the Chloroethanes at 25°C., kcal./g-mole

	Molecular Weight	$-\Delta H_f°$	$-\Delta G_f°$	Boiling Point, °C.	ΔH_v	Ref.
1-Chloroethane (g)	64.52	25.1	12.7	12.27	5.9	14
1,1-Dichloroethane (l)	98.97	36.4	....	57.4	7.3	14
1,2-Dichloroethane (l)	98.97	39.7	19.2	83.5	7.7	14
1,1,1-Trichloroethane	133.42	....	....	74.0	7.96[1]	14
1,1,2-Trichloroethane	133.42	....	....	113.9	8.8	14
1,1,1,2-Tetrachloroethane	167.86	....	....	130.5	8.8	14
1,1,2,2-Tetrachloroethane (g)	167.86	33*	....	145.	9.2	1, 14
Pentachloroethane (g)	202.31	35*	....	159.3	9.7	1, 14
(l)	.....	45*	....	....	....	....
Hexachloroethane (c)	236.76	48.	....	184.4	12.2[2]	14

$\Delta H_f°$ and $\Delta G_f°$ represent the changes in enthalpy and free energy, respectively, for the formation of the compound in the designated state from the elements carbon, hydrogen, and chlorine, with all reactants and products in their appropriate standard reference states. ΔH_v is the increase in enthalpy on vaporization from liquid to gas at 760 mm Hg.

(g) indicates gaseous state, (l) liquid state, (c) crystalline state.

* Values so indicated are from Bichowsky and Rossini (1), are rather old (1936) and unreliable. They are at 18° C. rather than 25° C.

[1] Heat of vaporization at 76.86 mm Hg., 13.37° C.

[2] Heat of sublimation.

The enthalpy functions, entropies and free energy functions are given in Tables 12, 13 and 14. Values on the Kelvin temperature scale can be transformed to any other temperature scale using the Lagrangian interpolation formula given by Kobe and Pennington.[9]

Incomplete data are available on the heats and free energies of formation at 25 C., given in Table 15. Most values are from a recent tabulation,[14] but three values are taken from a 1936 tabulation[1] which cannot be considered to have a high degree of reliability.

ACKNOWLEDGMENT

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About the Authors

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Fellowships enabled Harrison to devote a considerable portion of his school time to the calculation of the thermodynamic properties of industrially important compounds. Some of his work was also supported by a grant from the Office of Ordnance Research.

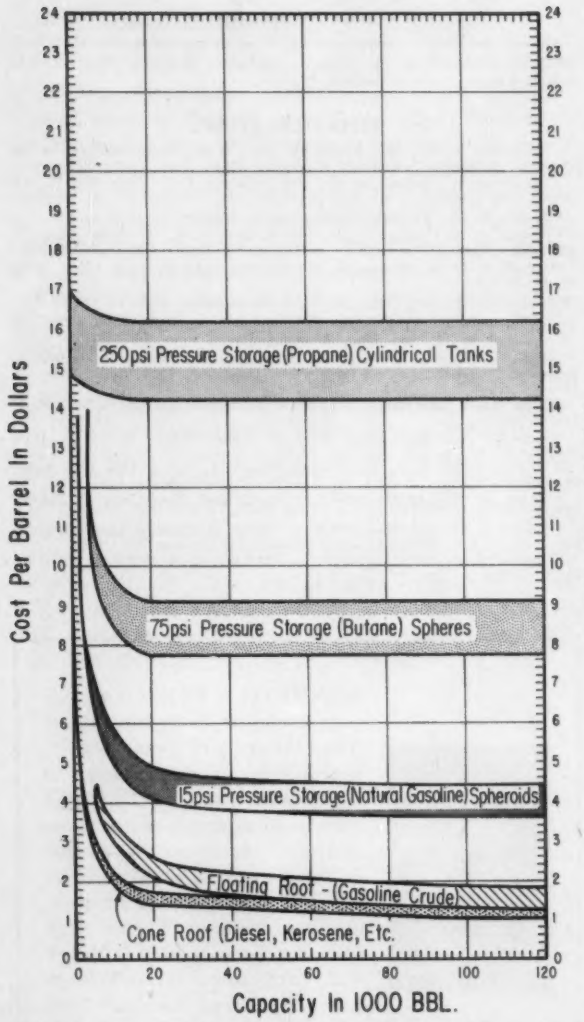
Cost Per Barrel In Dollars
250psi Pressure Storage (Propane) Cylindrical Tanks
75psi Pressure Storage (Butane) Spheres
15psi Pressure Storage (Natural Gasoline) Spheroids
Floating Roof - (Gasoline Crude)
Cone Roof (Diesel, Kerosene, Etc.
Capacity In 1000 BBL.

FIGURE 1—Construction cost ranges for above-ground storage using conventional steel tanks commonly used for the various hydrocarbons shown.*

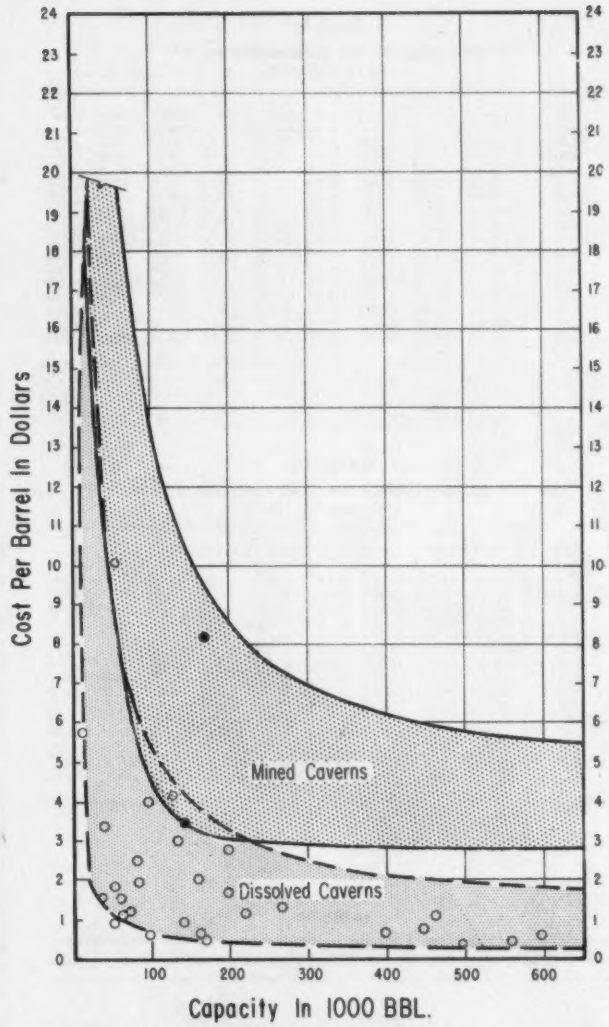

FIGURE 2—Construction cost for dissolved caverns and mined caverns for underground storage.* Reported cost: Circles show dissolved caverns; black dots, mined caverns.

*** Tanks or caverns complete with minimum connection piping. These established ranges are for normal conditions—do not include cost of land, loading racks, dehydrators or other similar equipment. Underground caverns include equipment to bring to surface.**

Is Underground Storage Competitive?

Underground storage is more economical than above-ground storage when large quantities are to be stored.

IT'S NOW KNOWN how much underground storage costs. A recent survey by The National Petroleum Council released in March of 1957 indicates that there are 90 underground storage reservoirs in operation in the U. S. The survey also shows the type of reservoir, product stored and location. (See Table 1.)

The competitive position of underground storage versus above-ground storage can be seen from Figures 1 and 2. This can best be shown by the following example:

Assume storage capacity for 100,000 barrels of propane is to be provided. Referring to Figure 1, the cost of above-ground storage for 100,000 barrels of propane ranges from $14.20 per barrel to $16.20 per barrel. Re-

ferring to Figure 2, underground storage for this same capacity of propane ranges from 70 cents to $13.80 per barrel.

Figures 1 and 2 show a comparison of estimated construction cost ranges for underground and above-ground storage of hydrocarbons.

The underground storage estimated construction costs are for mined caverns and for cavities dissolved from salt domes and salt beds.

Above-ground storage estimated construction costs are for steel storage tanks of the types commonly used for storage of low pressure fractions—crude oil, heating oil, motor fuel, natural gasoline fractions, etc.—and for liquefied petroleum gases.

From Figures 1 and 2 it may be seen that for products such as butane and propane, underground storage is more economical than above-ground storage when large quantities are to be stored and where conditions are such that underground storage can be constructed. Also, where conditions for underground storage are favorable and real estate costs are high, underground storage for normal liquid hydrocarbons such as motor fuel may be economically favorable.

Economic cost ranges shown are for comparable and normal conditions for both underground and above ground storage. The cost ranges include minimum connection piping but do not include cost of land, loading racks, dehydrators, or other similar equipment. However, underground storage cost ranges do include equipment to bring the product to the surface.

The economic factors that must be considered in the design and construction as well as the operation of underground storage facilities are numerous and include the following:

The factors affect underground storage economics

- **Type of product to be stored**
- **Geology of formation above storage formation**
- **Size of storage**
- **Method of product removal**
- **Operational rates required**
- **Storage costs**

A. Type of product to be stored
   1. Vapor pressure
   2. Permissible impurities
   3. Disposal of non-condensable gases
   4. Dehydration of product, if required
   5. Fractionation of product, if required

B. Geology of formation above storage formation
   1. Lost circulation zones
   2. Water bearing zones
   3. Heavy ground
   4. Structural strength
   5. Surface terrain
   6. Disposal of dissolved or mined spoil
   7. Depth of storage formation
   8. Proximity to other mining operations

C. Size of storage
   1. Well spacing (applicable to solution storage only)
   2. Completion time
   3. Thickness of storage formation
   4. Stability of formation
   5. Roofrock

D. Method of product removal
   1. Fresh water
   2. Brine
   3. Vapor lift
   4. Submersible pump

E. Operational rates required
   1. Large volumes—large casing for salt—big pumps on cavern
   2. Small volumes—small casings

F. Storage costs

TABLE 1—Underground Storage Projects in United States as of July, 1956

PRESENT USE OF STORAGE*	Alabama	California	Illinois	Kansas	Louisiana	Michigan	Mississippi	Missouri	New Mexico	New York	Ohio	Oklahoma	Pennsylvania	Texas	United States
Liquefied Petroleum Gas	..	1	1	2	2	..	2	..	1	..	..	..	..	10	19
Propane	1	..	3	1	1	2	..	..	1	1	1	2	..	14	27
Butane	..	..	..	..	..	1	..	..	..	..	..	..	..	4	5
Propane, Butane	..	..	2	2	1	..	1	..	5	1	..	1	..	14	27
LPG, Ethylene, Chemical	..	..	..	..	..	..	..	..	..	..	..	..	..	3	3
Propane & Iso Mix	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Propane & B-P Mix	..	..	..	..	1	..	1	..	..	..	..	..	..	2	4
Propane, Butane, Olefin	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Olefin Feed Stock	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Butane-Propane Mix	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Heating Oil	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Total Reservoirs	1	2	6	5	5	3	4	1	7	2	1	3	1	49	90
Type of Reservoir															
Solution Salt Cavity	..	..	..	5	5	3	4	..	7	2	..	1	..	43	70
Depleted Oil Reservoir	..	1	1	..	..	..	..	..	..	..	..	1	..	2	5
Depleted Gas Reservoir	..	..	..	..	..	..	..	..	..	..	..	..	..	2	2
Water Sand	..	1	1	..	..	..	..	..	..	..	..	..	..	1	3
Mined Reservoir	1	..	4	..	..	..	..	1	..	..	1	1	..	1	9
Quarry	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Total Reservoir	1	2	6	5	5	3	4	1	7	2	1	3	1	49	90

* Obvious overlap in product categories due to differing terminology used by companies when answering questionnaires.

Fluid Catalyst Design Data—Part 7

How to Predict Gravity Flow Rates

Use these equations and charts with flow rate correlations to quickly predict the flow rates for powders in free flow through restrictions.

Frederick A. Zenz,
Roslyn Harbor, Long Island, New York

Part VII reviews the major published studies in this field and offers equations and charts for predicting gravity flow rates, Part VI "Particle Size Affects Initial Fluidization" which appeared in the September PETROLEUM REFINER presented a key to better understanding of the observations reported in the field of fluidization by defining incipient fluidization as it relates to particle size distribution.

PROBABLY ONE of the earliest practical adaptations of solids flow through a restriction was the hour glass. Many egg timers still in use today are based on the calibration of any orifice passing bulk solids. Despite the age and common use of the mechanism, it is surprising how little published information can be found bearing generally on the prediction of flow rates for powders in free flow through restrictions. Table 1 presents a list of some of the major published studies in this field.

Specific Correlations. Newton et al studied the flow of 0.1 inch catalyst particles through various size openings. They found that for their particular catalyst the flow, Q_A, in lbs/second was a function of the orifice diameter, D_o, in inches, and of the head, H, in feet of solids above the orifice as given by the expression:

$$Q_A = 0.1416\ D_o^{2.98}\ H^{0.04} \qquad (1)$$

This formula was found to hold in cases where the orifice diameter is greater than six times the particle diameter.

Kelley reported that for 2, 3 and 4-inch orifices the flow of bead or pellet catalyst in lbs/second fits the equation:

$$Q_A = 0.156\ D_o^{2.84} \qquad (2)$$

Gregory presented an equation relating to stick-slip downflow of powders in pipes as:

$$Q_A = 0.278\ D_o^{2.5} \qquad (3)$$

He also suggested the following rules for the flow of particulate solids in pipes:

1 The internal diameter of the conduit should exceed 5 to 7 times the diameter of the largest particles where they are present in high proproportions.

2 Materials of narrow size range flow best; wider size ranges exhibit increasing tendency to stick.

3 Mild steel pipe causes sticking more readily than stainless steel or glass.

4 Surface moisture should be kept below 1 to 2 percent.

5 Fine materials of particle size less than 0.003 inches have a pronounced tendency to stick.

The last observation is particularly interesting in relation to experiments reported by Beilby[2]. Beilby found that filings of zinc, gold, silver or copper having a particle size smaller than 0.004" will adhere not only to the surface of any metal, but to glass, porcelain, etc. Observations, with a microscope, of a glass slide dipped into and withdrawn from a bed of filings, showed that the particles hung from the bottom of the slide in the form of long chains. These chains were composed of particles adhering one to another, with the uppermost adhering to the underside of the slide. This was observed only with particles smaller than 0.004" in diameter.

Shirai correlated the flow of sand, quartz, and active-earth powder (30 to 150 mesh) through 0.09 inch to 0.355 inch diameter orifices by means of the equation:

$$Q_A = \frac{0.00383\ \rho_B\ D_o^{2.5}}{\mu^{1/2}}$$

where:

Q_A = solids flow, lbs/sec.
ρ_B = solids bulk density, lbs/cu. ft.
D_o = orifice diameter, inches
μ = coefficient of friction

For μ equal to 1, and a bulk density of 45 lbs/cu. ft., which corresponds to bead catalyst, Shirai's equation reduces to

$$Q_A = 0.173\ D_o^{2.5} \qquad (4)$$

In view of the possible discrepancies in particle sizes

TABLE 1—Reported Quantitative Studies of Gravity Flow of Bulk Solids

Investigator	Reference	Source	Vessel	Particle Size Microns
1) J. Delaplaine.....	Forces Acting in Flowing Beds of Solids	Ph.D. Thesis, Univ. of Delaware 1953	1/32" orifice	250 to 750
2) W. E. Deming and A. L. Mehring	Gravitational Flow of Fertilizer and Other Cominuted Solids	Ind. and Eng. Chem. **21,** 661 (1929)	0.118" to 0.593" orifices	160 to 3530
3) F. C. Franklin and L. N. Johanson	Flow of Granular Material Through a Circular Orifice	Chem. Eng. Sci. **4,** No. 3, 119-129 (1955)	0.236" to 2.28" orifices	765 to 5080
4) S. A. Gregory	Problems of Plant Design for Fluidized Processes	J. Appl. Chem. **2,** Suppl. issue No. 1, S1-S7 (1952)	1" to 50" pipes	.....
5) A. Herrmann	Flow Characteristics of Brown Coal Fines and Other Powdered Materials	Bergbau No. 18, 75-91 (1953)	3 mm to 8 mm orifices	60 to 250
6) A. E. Kelley	Measurement of Solids in TCC Process	Petroleum Engineer **16,** No. 13, 136-42 (1945)	2", 3" and 4" orifices	3000
7) C. Kojabashian	The Properties of Fluidized Solids in Vertical Downflow	B.S., M.S. Theses M.I.T. June, 1954	1" pipe	60
8) W. Kroll	Flow Phenomena in Solid Charges of Vibrating Containers	Chem. Ing. Tech. **27,** 33-8 (1955)	4" x 7" box	120
9) G. Kuwai	Flow of Solid Particles Through an Orifice. Flow Rate of Particles Under Low Air Pressure	Chem. Eng. (Japan) **17,** 453-9	0.0785" to 0.312" orifices	.....
10) R. H. Newton, G. S. Dunham and T. P. Simpson	The TCC Catalytic Cracking Process	Trans. A.I.Ch.E. **41,** 215 (1945)	1", 2", 3", and 4" orifices	4000
11) Y. Oyama and K. Nagano	Discharge Rate of Solid Particles from a Nozzle Steeped in Liquid	Rept. Sci. Res. Inst. (Japan) **29,** 349-52 (1953)	.....	250 to 2500
12) J. M Rausch	Gravity Flow of Solid Beds in Vertical Towers	Ph.D. Thesis, Princeton, 1948	1/16" to 2" orifices	127 to 15,000
13) C. E. Shanahan and J. Schwarz	Characteristics of Solid Flow in a Standpipe	M.S. Thesis, M.I.T. June, 1954	1" pipe	100
14) T. Shirai	Powder Orifice Nomograph	Chem. Eng. (Japan) **16,** 86-9 (1952)	0.09" to 0.355" orifices	100 to 600
15) K. Takahashi	Experimental Investigation of the Efflux of Granular Mass	Bull. Inst. Phys. Chem. Res. (Tokyo) **12,** 984-94 (1933)	.....	.....
16) E. F. Wolf and H. L. Von Hohenleiten	Experimental Study of the Flow of Coal in Chutes at Riverside Generating Station	Trans. A.S.M.E. **67,** 585-599 (1945)	2" to 12" pipe	3000

of bead catalyst, Equations (1) and (2) show rather good agreement. Similarly Equation (4), which is based on approximations of the bulk density and an assumed zero friction for bead catalyst, also yields about the same results. Equation (3) which is reportedly a "safe" general approximation actually gives higher flow rates. The supporting data for equation (3) have never been published; it is quite likely that the apparatus was so arranged as to induce higher than normal flow rates. For example, the flow rate from a bin with a hole in the center of a conical bottom is much greater than that from a bin with a hole in the center of a flat bottom.

TABLE 2

Characteristics of Solids Used in the Experiments of J. M. Rausch

PARTICLES	Particle Diam., Ins.	Bulk Density, Lbs./Cu. Ft.	Normal Percent Voids	Poured Angle of Repose, Degrees
Radish seed	0.098	45.5	41.0	38
Soy beans	.302	47.7	34.4	39
Socony beads	.170	45.5	43.5	35
Alumina spheres	.591	138.	38.5	43
Alumina spheres	.447	127.	33.1	38
Alumina spheres	.276	129.	38.4	34
Steel ball bearings	.344	313.	35.5	33
Steel ball bearings	.500	301.	38.0	37
Lead shot	.050	420.	37.5	23
Lead shot	.250	410.	43.0	33
Lead shot	.150	411.	41.8	30
Sea sand	.0198	91.	42.5	37
Sea sand	.0100	85.5	44.7	36
Sea sand	.0071	84.7	44.2	36
Sea sand	.0050	84.7	44.2	35
Iron powder	.0141	148.	48.0	42
Iron powder	.0100	152.	48.1	41
Iron powder	.0071	140.	48.0	40
Iron powder	.0050	138.	48.0	40
Glass beads	.0113	91.6	38.6	26
Glass beads	.205	85.0	42.1	32

The Generalized Correlation. In 1948 Rausch completed a thesis on the subject of gravity flow of solids through orifices. This work represents the most exhaustive single study reported to date. Rausch's data were taken in tubes from 3 inch to 8 inch in diameter and orifices 1/16 inch to 2 inch in diameter; the particles varied widely in size, shape, and density, as shown in Table 2. The data were correlated as shown in Figure 1, as a plot of orifice to particle diameter ratio, D_o/D_P versus

$$\frac{Q_A \sqrt{\tan \beta_A}}{CC_o \sqrt{g}\, \rho_B D_P^{2.5}}$$

In this construct Q_A, ρ_B, and β_A are all based on conditions in a medium of atmospheric air. To calculate the flow rate, Q_M, in other media, Figure 1 is first used to obtain Q_A and this value corrected to that in the medium of interest by the relationship (see nomenclature in Figure 1 caption):

$$Q_M = Q_A \sqrt{\frac{\tan \beta_A \,(1 - \rho_M/\rho_P)}{\tan \beta_M}}$$

Wall Effects. The value of C in the ordinate of Figure 2 is a wall effect correction factor on the bulk density. If the diameter of the particles is small compared with the diameter of the orifice or of the containing vessel, the

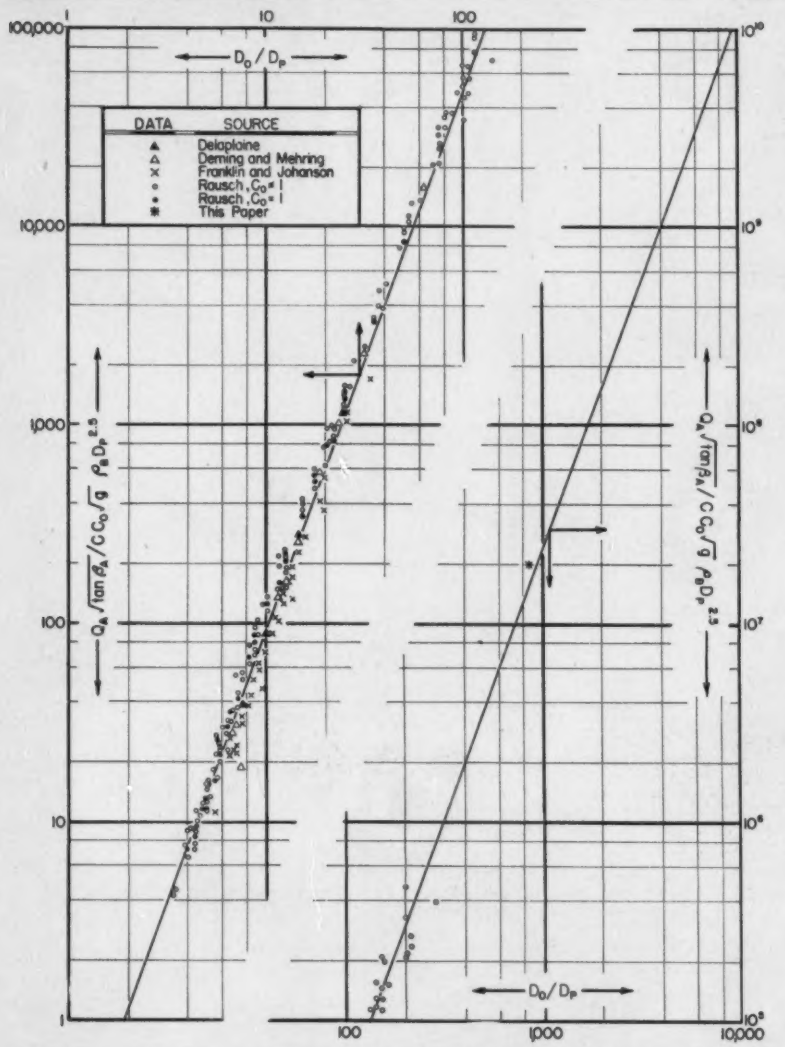

FIGURE 1—Correlation of data on gravity flow of solid particles through vertical pipes, orifices, and conical-bottom hoppers. This chart can be used to predict maximum gravity-flow discharge capacities of pipes and orifices under essentially zero fluid pressure. In media other than standard air:

$$\frac{Q_M}{Q_A} = \sqrt{\frac{\tan \beta_A \ (1 - \rho_M/\rho_P)}{\tan \beta_M}}$$

NOMENCLATURE

Q_A = Solids flow rate in standard air, pounds per second

β_A = Angle of repose of solids in standard air

g = Acceleration of gravity, 32.2 feet per second x second

ρ_B = Normal bulk density of solids, pounds per cubic foot

D_P = Particle diameter, feet

D_O = Orifice or pipe diameter, feet

Q_M = Solids flow rate into surrounding medium, pounds per second

ρ_P = True density of particles, pounds per cubic foot

ρ_M = Density of surrounding fluid medium, pounds per cubic foot

β_M = Angle of repose of solids in surrounding medium

C = Bulk density of wall effect correction (see Figure 2)

C_O = Correction factor for cone angle at bottom of hopper (see Figure 3)

average density of the material in the cross section is essentially equal to the density at the center. The actual condition at the wall of a packed bed of solids can be visualized by placing an imaginary cylinder vertically in a large bed and eliminating every particle cut by the cylinder.

Verman and Banerjee[15] showed that if in an infinite container this removal of particles cut by the imaginary cylinder had no effect on the second layer of particles from the wall, the ratio of overall density to density at the center would be given by:

$$\frac{\rho}{\rho_B} = \left(\frac{\eta - 1}{\eta}\right)^2 \qquad (5)$$

where η represents the ratio of orifice to particle diameter or of tube to particle diameter.

Zhavoronkov et al[17] extended this analysis of wall effect to take into account the additional effects on the second layer of particles from the wall and derived the relationship:

$$C = \frac{\rho}{\rho_B} = \left(\frac{\eta - 1}{\eta}\right)^2 + 0.5\left[1 - \left(\frac{\eta - 2}{\eta}\right)^2\right] = 1 - \frac{1}{\eta^2} \qquad (6)$$

Equation (6) is again based on an infinite bed depth of spherical particles. In a finite depth a similar wall effect occurs at the bottom and top of the bed. For the case in

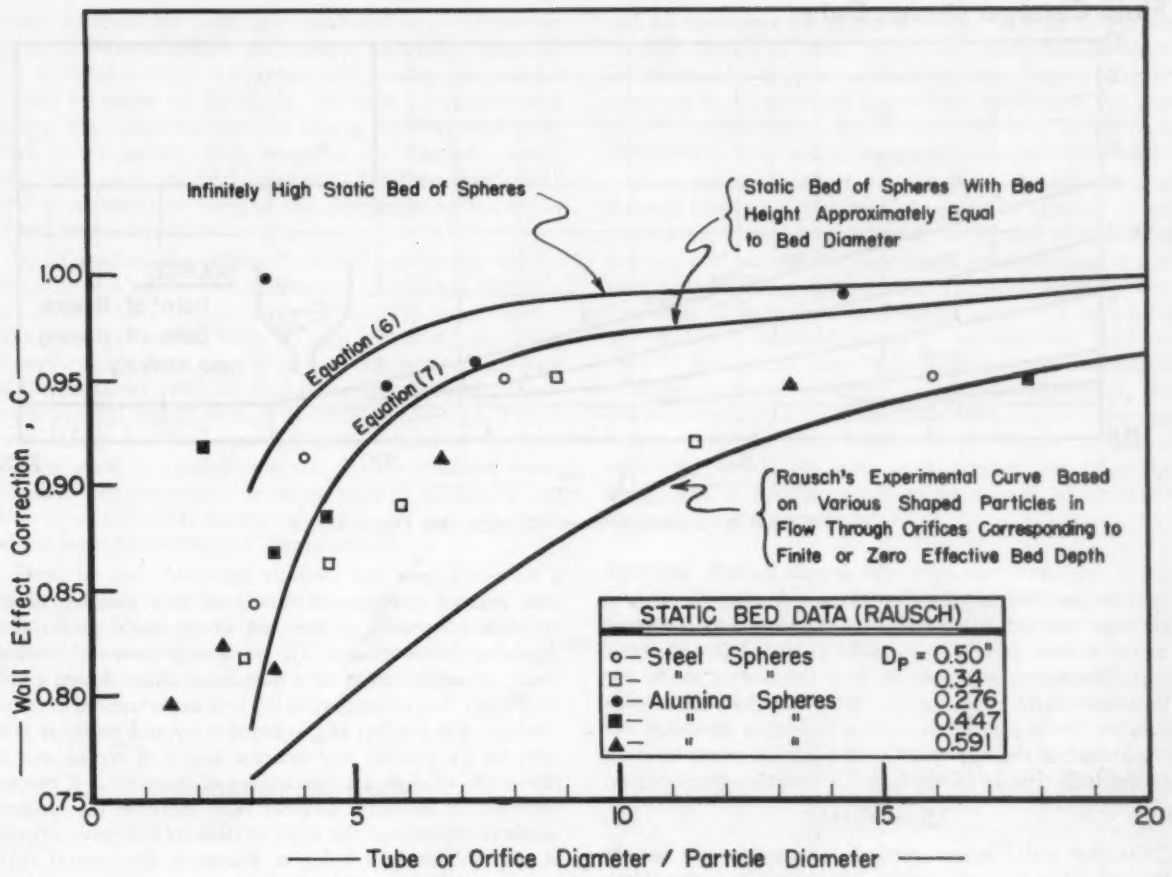

FIGURE 2—Wall effect correction factor.

which the bed height is equal to the bed diameter, this additional voidage introduced reduces the value of C to:

$$C = \frac{\rho}{\rho_B} = \left(\frac{\eta - 1}{\eta}\right)^3 + 0.5\left[1 - \left(\frac{\eta - 2}{\eta}\right)^3\right] \qquad (7)$$

In considering the general case of flow of solids through orifices, neither Equations (6) nor (7) can be expected to fully represent the mechanics of flow. Certainly the conditions at an orifice can be likened to some finite bed height, approaching one particle diameter in depth. Thus Equation (7) would be expected to be more representative than Equation (6), but probably still not accounting fully for the voidage introduced by the "effective" bad depth. At very low or very high values of η, however, this additional bed depth effect would be overshadowed by the orifice wall effect alone.

The derived equations are based on an analysis of static beds of spheres, whereas in practical applications the material passing through an orifice is in a state of flow. In addition, the question of particle shape effect would almost certainly require experimental rather than analytical treatment. Shaffer's[14] data showed that, in general, the wall effect was greater for cylinders than for spheres. All of these considerations are effectively summarized in Figure 2.

Hopper Cone Angle Effects. The factor C_o, in the ordinate of Figure 1 corrects the flow rate from flat-bottomed bins to that from hoppers with inclined sides. C_o is a function of the angle between the inclined sides and the horizontal, and also the ratio of orifice-to-particle diameter. The empirical function determined by Rausch in correlating his data to conform to Figure 1 with minimum deviations is shown in Figure 3. At the upper range of orifice to particle diameter ratio the angle of internal friction, α, (see Figure 4 in Part 1 of this series) overshadows the effect of changing the hopper slope Θ. As Θ approaches or exceeds α its effect becomes detectable. The full significance of α has not been incorporated in Figure 3; in any event the effect is relatively minor for most practical cases.

Additional Data and Related Studies. In conjunction with a study of the interparticle and wall forces in downflowing beds of solids, Delaplaine observed the efflux of various size sand particles through four 7/32 inch holes in the base of a 3.8 inch diameter tube. His data are also shown in Figure 1. In 1955 Franklin and Johanson published data on the flow of particles through orifices which again show excellent agreement with Figure 1.

A number of papers have appeared in the literature at various times related to this field, but usually too spe-

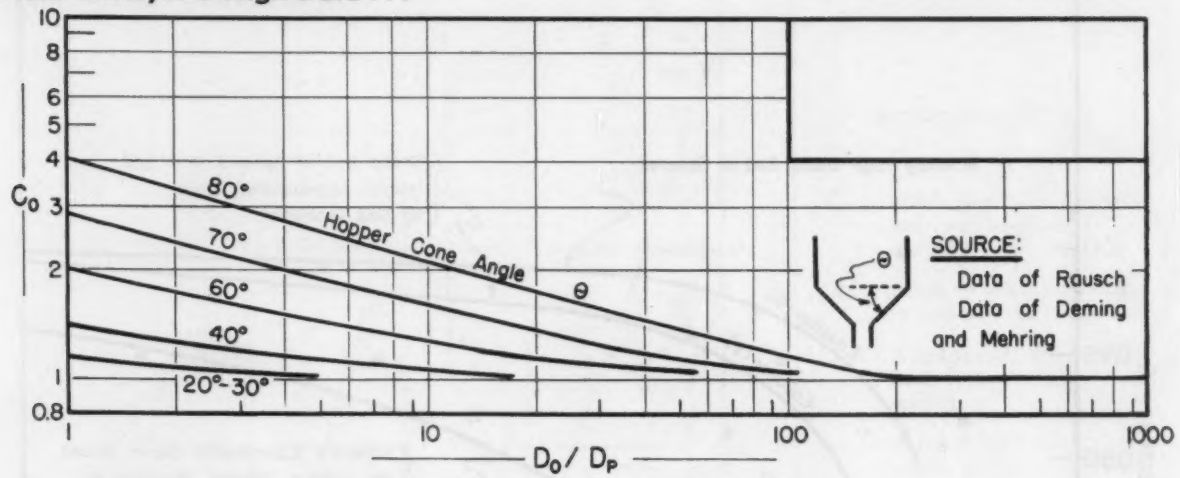

FIGURE 3—Correction factor C_o angle (see Figure 1).

cific for general applicability. Kuwai studied the flow of particles through 0.019 inch to 0.312 inch orifices located in the bottom of 0.75 inch to 2.125 inch I.D. cylindrical bins. He introduced aeration into the bed of solids and thus materially increased the flow. For the case of bead catalyst flowing through orifices having a diameter one tenth that of the bin vessel with aeration pressure equal to the bulk density of the bed, his equation simplifies to:

$$Q_A = 0.82\ D_o^{2.75} \tag{8}$$

Oyama and Nagano carried out experiments on the flow of solids through nozzles submerged in water. Their results correlated with the expression:

$$Q_A = \frac{f\,[\,[D_P^{1.5}(\rho_P - \rho_f)\,]/\mu_f]^n}{\varepsilon_{mf}^{5}}\, D_o^{2.5} \tag{9}$$

where D_P is the particle diameter, ρ_P the particle density, ρ_f the fluid density, μ_f the fluid viscosity, and ε_{mf} the voidage in the bed of solids at its loosest bulk density. Note that the exponent on the orifice diameter is again the same as in equations (3) and (4). The numerator is an empirical function with the exponent n also a dependent variable.

Takahashi in 1933 reported a correlation of the flow of solids through orifices in the form:

$$Q_A = k_1 D_o^{2.5} / [f(\tan \beta) + k_2(D_P/D_o)] \tag{10}$$

where k_1 and k_2 are constants dependant on the material being handled. Similarly f $(\tan \beta)$ is an empirical function of the angle of repose of the solids.

Gunderson[5] studied the effect of inclining the orifice. He correlated his results in terms of the ratio of flow from the inclined orifice to flow from the horizontal orifice as

$$\frac{(Q_A)_{\Theta'}}{Q_A} = \frac{\cos \beta' + \cos \Theta'}{\cos \Theta' + 1} \tag{11}$$

where β' is a so-called kinetic particle angle of repose and Θ' is the angle of inclination formed by the horizontal and the plane of the orifice.

Wolf and Von Hohenleiten presented a study of the flow of coal in chutes. The experimental investigation, in transparent scale models, involved observation of the factors causing stoppage of flow and an evaluation of the physical properties of the coal which might give rise to bridging characteristics. The authors present the development, in model scale, of a particular chute design giving improved flow characteristics. Their experimental determinations of the effect of packed density and moisture content on the poured and drained angles of repose and on the angle of slide are particulary of interest. A 1 percent increase in moisture content may increase the drained angle of repose and the angle of slide by 5 degrees whereas it may only cause a 1 degree change in the poured angle of repose. The particles had a mean diameter of 3000 microns but varied from about 15,000 down to 200 microns. The angles of slide and repose showed maxima in the neighborhood of 12 percent moisture content.

Herrmann also carried out a detailed study of the flow characteristics of powders again with particular ref-

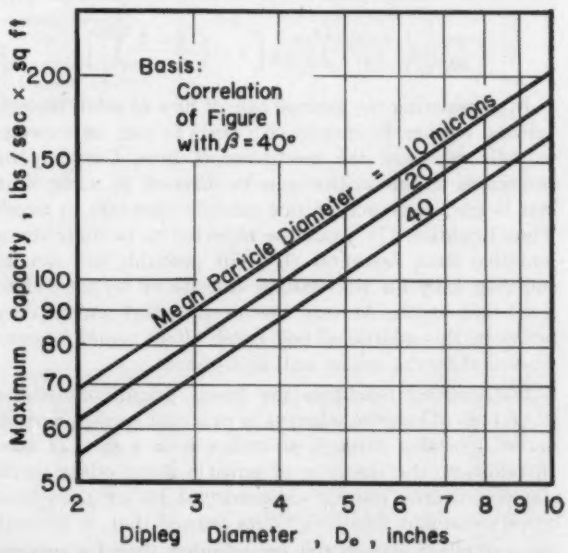

FIGURE 4—Dipleg capacity for cracking catalyst of 20 pounds per cubic foot downflow density. These curves are based on a fixed bulk density.

erence to coals. His technique was based on a comparison of the time required for emptying a standard volume of the material through a standard orifice with the time required by water at 20 C. in the same apparatus and orifice. He concluded that the laws of hydrodynamics applied to the powder feed; however, the apparatus could only hold such low bed heights (7.5 inches maximum) that in all instances the flow was dependent on the depth of bed above the orifice.

Kroll studied the effect of vertical oscillations on the behavior of a bed of sand particles of 120 micron diameter in a 4 inch by 7 inch rectangular box. He noted that at 100 cycles per second, with 0.3 mm amplitude, the solids flowed readily from an orifice near the base of one side of the container. This oscillation corresponded to a maximum vertical rate of motion of 0.618 feet/second. This is well above the incipient fluidization velocity for 120 micron sand in atmospheric air. In the fluidized state, powders will approach the characteristics of liquids and flow at considerably higher rates than in the bulk state, where high frictional coefficients prevail.

Deming and Mehring studied the flow rates of a variety of particles through orifices at the bottom of a cone shaped hopper. Their cone angles, as defined in Figure 3, were 45 degrees, 60 degrees, and 75 degrees. They correlated their data by the relationship:

$$t = \frac{k}{D_o^{2.5}\,\rho_B}\left[\,0.201 + (0.392 + 2.58 \sin [90 - \Theta]) \left([D_P/D_o] + 0.130 - 0.161\,k\right)\right] \qquad (12)$$

where:

t = time in hours to discharge one ton of solids (2000 pounds)
D_O = orifice diameter in feet
D_P = particle diameter in feet
ρ_B = solids density in lbs/cu. ft.
Θ = cone angle as defined in Figure 3
k = coefficient of friction

The authors published their data on two materials investigated. Unfortunately the general applicability of their equation requires some means of predicting the coefficient of friction for any arbitrary material. The values of k reported by Deming and Mehring were actually calculated from their own flow data as a correlating constant. However, their published experimental data agree perfectly with the Rausch correlation of Figure 1 which does not require a knowledge of k, but rather the readily measurable angle of repose. It should also be noted that Deming and Mehring's data on the effect of cone angle are also in excellent agreement with Figure 3.

In addition to the references already cited, Table 1 lists the quantitative studies of solids downflow in pipes carried out by Kojabashian and by Shanahan and Schwarz. These investigators did not attain ultimate pipe capacity in the sense of Figure 1, but studied instead the relationship between flow conditions and pressure differential in a straight section of pipe at lesser downflow rates. Their data have been shown elsewhere[16], plotted in terms of the so-called "Fluid-Solids Phase Diagram."

Equations (1) through (4) can be compared to the correlation of Figure 1 using 0.12 inch as the diameter of bead catalyst, 40 pounds per cubic foot as the bulk density, and 38 degrees as the angle of repose. In view of the less exacting nature of these studies the agreement obtained is considered adequate to conclude that Figure 1 can be accepted as an excellent generalized correlation for predicting the maximum gravity-flow discharge capacity of pipes and orifices under essentially zero fluid pressure.

In applying Figure 1 to the flow of FCC catalyst through reasonable size restrictions a fair amount of extrapolation is required. In order to obtain some partial indication of whether such extrapolation is reasonably correct, a batch of FCC catalyst was drained from the bottom of a 12 inch diameter vessel through a 2 inch hole. The bed was relatively shallow, and the run time less than 15 seconds, so that the data could not be considered as very accurate; however, as shown in Figure 1, the plotted result does indicate that at least some extrapolation is valid. Experimentation in the higher ranges of orifice to particle diameter ratio requires very large size equipment to handle the necessary circulated inventory for runs of significant duration.

Cyclone Dipleg Capacity. The use of Figure 1 can best be illustrated with reference to typical calculations. Consider the problem of minimum dipleg diameter for the first stage cyclone of a fluid cracking unit in which the pressure balance has been made so tight that an additional frictional loss buildup of solids in the dipleg is not tolerable. Assume that entrainment calculations gave 2100 grains per cubic foot or 22.6 lbs./sec. as the cyclone loading with an average particle size of 40 microns. The ordinate of Figure 1 is therefore 22.6 x (tan 40 degrees)$^{1/6}$/(32.2)$^{1/6}$ x 20 x (0.000131)$^{2.5}$ or approximately 924,000,000 and the corresponding abscissa is 3820. Dipleg diameter is therefore 3820 x 0.000131 x 12 = 6 inches.

Figure 4 shows the results of similar calculations for average particle sizes ranging from 10 to 40 microns. It is interesting to compare these results with the general rule of thumb based on a fixed lbs/sec x sq. ft. capacity figure. For example, if 115 lbs/sec x sq. ft. was arbitrarily set as the design rate for all diplegs then the second stage dipleg which would be smaller than the first stage because of the lower downflow rate, would be undersized since the ultimate capacity decreases with decrease in pipe size. If the bulk density does not change appreciably with mean particle size then the increase in capacity with decrease in second stage particle size may offset the decrease in capacity with decrease in dipleg diameter. The curves of Figure 4 are based on a fixed bulk density; actually the smaller particle sizes would exhibit some lower bulk density which would tend to make the curves coincide more nearly with that for the 40 micron particles.

Moving Bed Process Application. An even more direct problem is met in sizing any of the catalyst piping or grid work in a moving bed cracking unit. Consider for example the question of sizing the catalyst line leading from the reactor down to the kiln of a TCC unit. The bead catalyst is approximately 0.12 inch in diameter and has an angle of repose of 38 degrees; the desired circulation rate is 310 tons/hour. Assuming that the pipe size will be large compared to the particle size (this assumption can be checked after the pipe size is calculated, and the procedure repeated if necessary) the ordinate of Figure 1

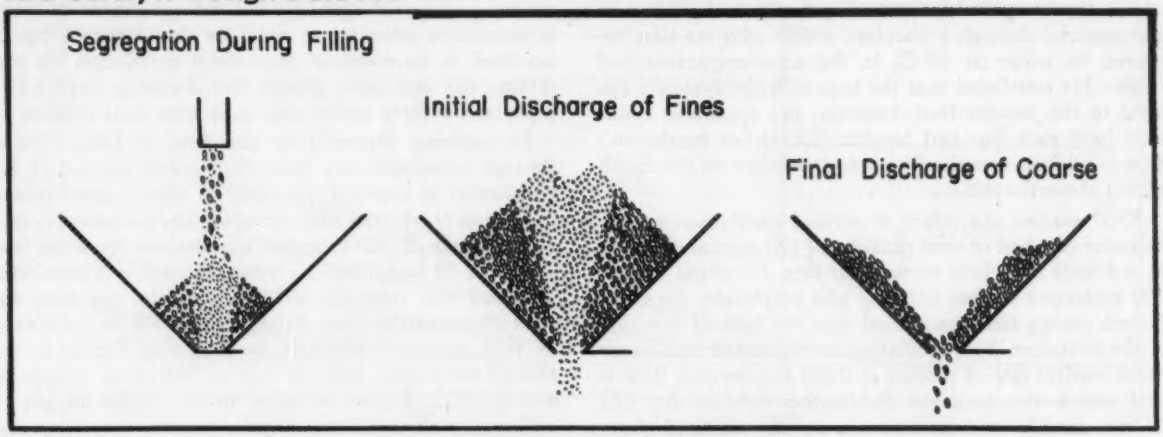

FIGURE 5—Segregation during filling and non-uniform discharge from bins and hoppers. Note that this segregation and non-uniform discharge is mainly produced during filling. Presumably any change that tends to prevent rolling of particles during filling will result in a more uniform mixture within the bin and therefore a more uniform discharge.

is found to be 310 x 2000 (tan 38 degrees)$^{1/2}$/45 x $(32.2)^{1/4}$ x $(0.01)^{2.5}$ 3600 or approximately 60,500. From Figure 1 $D_o/D_P = 109$, and the minimum pipe size is 109 x 0.120 = 13.1 inches I.D. Obviously the reverse procedure can also be employed if it is desired to calculate the maximum handling capacity of an existing unit for various solid catalysts.

Mixing and Distribution of Solids Flow. In shaft type furnaces, such as the blast furnaces, in moving bed cracking and adsorption units, in pebble heaters, and in bins, hoppers or other solids surge capacity vessels used with any equipment requiring a uniform quality or quantity of feed, the tendency of the particulate material to segregate whenever it is moved often causes serious difficulties. Most such processes also require uniform downflow rates and uniform solids size distribution across the vessel cross section. If this is not attained there occurs maldistribution of process fluids passing through the bed as well as undesirable temperature distributions.

Segregation. In piling ore or in filling bins, the solids form a cone-shaped pile. The apex of the cone is directly below the feed point and the surface forms an angle with the horizontal referred to as the poured angle of repose (see Part I of this series). If the process of pouring a mixture of particle sizes is observed closely it will be seen that the finer particles tend to remain directly below the feed point and the coarser particles tend to roll down the slope and collect near the base of the cone. Obviously when the pile is limited in size by the sides of a bin the contents of the filled bin will appear very segregated; the center portion will constitute nearly all fines while the coarse particles will be collected around the periphery. An excellent photographic study of such segregation of particle sizes has been presented by Davis.[4]

Segregation within a hopper may in itself be relatively unimportant; however, when it is emptied the coarse and fine particles do not discharge together. Assuming that all the contents are withdrawn through a single hole at the center of the base, it will be found that material with a large excess of fines is discharged first. Then, depending on the dimensions of the filled portion of the bin, the analysis of the discharge will either become increasingly coarse or fluctuate for a period of time until finally, when almost empty, the last material will consist almost entirely of the coarse particles.

Figure 5 illustrates this effect in an exaggerated form. The important point to be noted is that this segregation and non-uniform discharge is mainly produced during filling. Presumably any change that tends to prevent rolling of particles during filling will result in a more uniform mixture within the bin and therefore also a more uniform discharge.

The first suggestion to come to mind is the use of a travelling feed point so as to effectively feed the bin more uniformly over the cross section rather than at a single central point. Peacock[11] reported such experiments using a model bunker fed with a back and forth motion simulating a shuttle band conveyor feeder. For comparison he

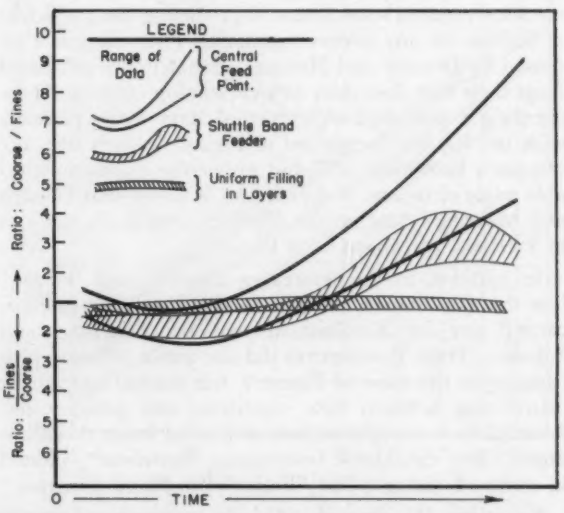

FIGURE 6—Effect of filling method on uniformity of discharge from bins and hoppers. Shown here are the effects of three filling methods as a function of time.

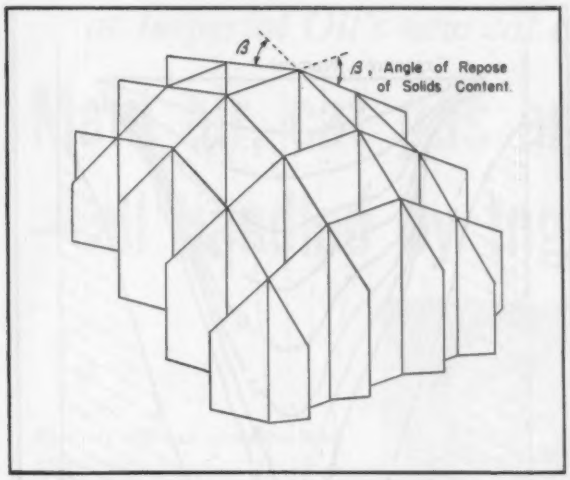

FIGURE 7—Isometric of "eggcrate" bunker partitions. Use of this design gave discharge curve, such as in Figure 6, identical to the case of uniform filling.

fed the bunker from a central feed hopper and then also repeated the tests filling the bunker very uniformly by spreading the solids in layers with a glass tube feeder. The particles were allowed to flow out of the tube slowly without falling any distance or forming heaps. The results were expressed graphically plotting excess coarse (ratio of coarse volume to fines volume), or excess fines (ratio of fines volume to coarse volume) as shown by analyses of the discharge, versus time. The feed material was a specially prepared mixture of coal particles having an equal volume of particles greater than 10 mesh (the coarse) and smaller than 10 mesh (the fines). Figure 6 gives the comparison of the three filling methods as a function of time.

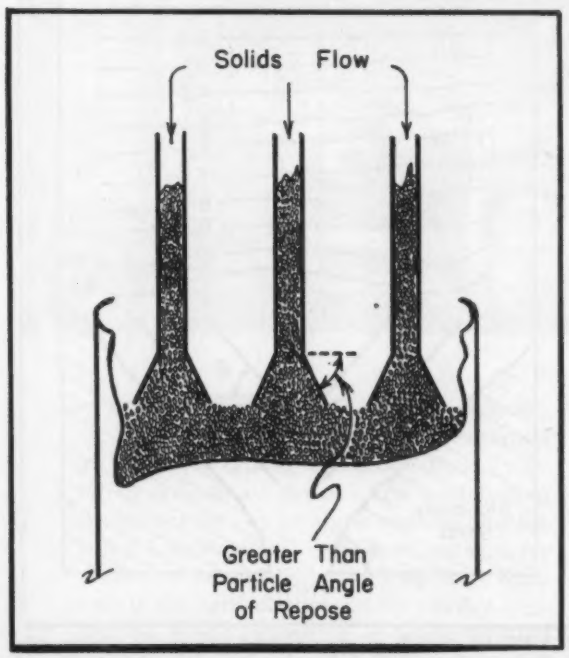

FIGURE 8—Sketch showing the use of multiple feed pipes with "bell" or conical outlets. This shows the advantages inherent in these devices.

The foregoing experiments relate to relatively shallow or low L/D bins. It has been observed experimentally that in tall and narrow bunkers provided with a central draw-off, the contour of the surface of the contained bed remains flat during discharge, indicating that the contents are descending uniformly and any horizontal segregation is counteracted by remixing before emerging from the discharge opening. During the filling of such a hopper, segregation is also minimized because any tendency for large particles to travel outwards is corrected by rebounding from the walls, and in any case, the high L/D ratio will generally prevent any segregation which may take place during filling from having an appreciable effect.

L. C. Bearer[1] was issued a patent on the basis of his claim that uniform downflow of solids across the cross-section of a pebble heater could be obtained above a distance of 1.7 vessel diameters measured from the discharge point. A few simple experiments with various powders will immediately show that the L/D ratio, above which downflow is uniform, and below which a depression begins to form in the surface of the bed of solids is another manifestation of the angle of internal friction (see Part 1 of this series). At an L/D exceeding the tangent of α, uniform downflow is obtained.

In general, such high L/D bins are more costly to build since in most cases more than one would be required. It has been suggested that a type of egg crate partition be installed inside a large bunker to break it up into essentially a number of small ones of high L/D. With a central feed point, the center partition of the egg crate is filled first and then the material spills over and feeds the next adjacent partitions etc. It has been found experimentally that if the upper edges of the egg crate are sloped toward the bin walls at the angle of repose of the solids, all compartments will be filled before any segregation can occur.

Figure 7 illustrates the experimental egg crate baffles which yielded a discharge curve, such as in Figure 6, identical to the case of uniform filling. In moving bed petroleum catalytic cracking units where both uniform downflow and uniform particle size distribution are required, multiple feed points are employed.

Lassiat, Savage[8] and Shirk[13] were issued patents relating to the use of a multiplicity of tubes feeding solids to the top of a large diameter bed. In an attempt to improve still further on uniform distribution, Shabaker[12] patented the use of conical outlets on the distributing tubes. Figure 8 illustrates the advantages inherent in these devices.

Uniform Downflow. Uniformity of downflow is of even greater concern in the design of moving bed processes than the problem of suppressing particle size segregation. In most instances, the vessel L/D is not sufficient to exceed tan α and automatically provide uniform flow. Internal drawoff devices must be designed to guide and control the solids flow. Davis[4] reported the development of a system of baffles for obtaining uniform unsegregated downflow of broken ore in bins or roasting furnaces.

The experiments were carried out in a thin rectangular bin with glass sides permitting observation of the flow. The ore particles were large enough to permit coloring

individual pieces to observe the flow pattern in the bed.

Figure 9 shows a sketch of a photograph of the model bin during discharge. The photograph was obtained using one piece of film exposed at 60 second intervals for 9 minutes without moving the camera. The solid lines represent the flow contours at each exposure, or one minute intervals. The dashed lines were drawn connecting the large colored pieces to show the paths followed by the particles in downflow.

In order to attain uniform downflow, a set of inclined baffles was installed in the bottom of the model bin and by means of the photographic technique described above, the flow profiles of Figure 10 were obtained. The baffles were sloped at the drained angle of repose, were kept horizontal at the top, and had a constant solids discharge open area. The design of such baffles for a particular installation is not entirely a simple and straightforward matter. It generally requires some degree of experimentation in every instance; small changes in baffle length or spacing can radically change the flow profiles.

Morse[9] patented the adaptation of the diamond shaped deflector alone as a means for obtaining uniform downflow; he gives specific rules for the sizing of the deflector. Another form of baffling system was recently reported by Brown[3]; he suggested that horizontally disposed rods, appropriately located, can make a bin truly "top discharging" and suppress segregation. The laws governing the spacing of the rods have not been investigated. The rods serve a function similar to hinged flaps in partitioned bins.[6]

Johnson[7] patented the use of a series of horizontally disposed perforated plates having progressively less holes such that each hole draws from four above. The plates are spaced at such intervals that the angle formed with the horizontal by a line connecting the nearest holes of two adjacent plates is greater than the angle of repose of the solids. This system of perforated plates was used in early models of moving bed catalytic cracking units. A good deal of experimentation on the flow characteristics of solids has been carried out in this connection.

Modern moving bed units employ the multiple feed principle in reverse; catalyst is withdrawn from the reactor through a multiplicity of drawoff tubes leading from a grid level to a common duct and thence to the kiln. Noll et al[10] have presented an excellent description of the method of withdrawing both product gases and solids from a commercial thermofor catalytic cracking unit.

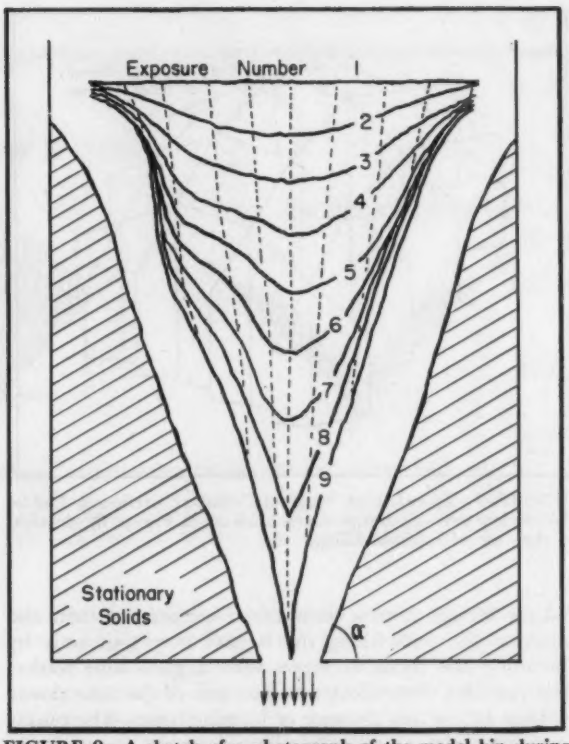

FIGURE 9—A sketch of a photograph of the model bin during discharge. The photograph was obtained using one piece of film exposed at 60-second intervals for 9 minutes without moving the camera. The solid lines represent the flow contours at each exposure, or one minute intervals. The dashed lines were drawn connecting the large colored pieces to show the paths followed by the particles in downflow.

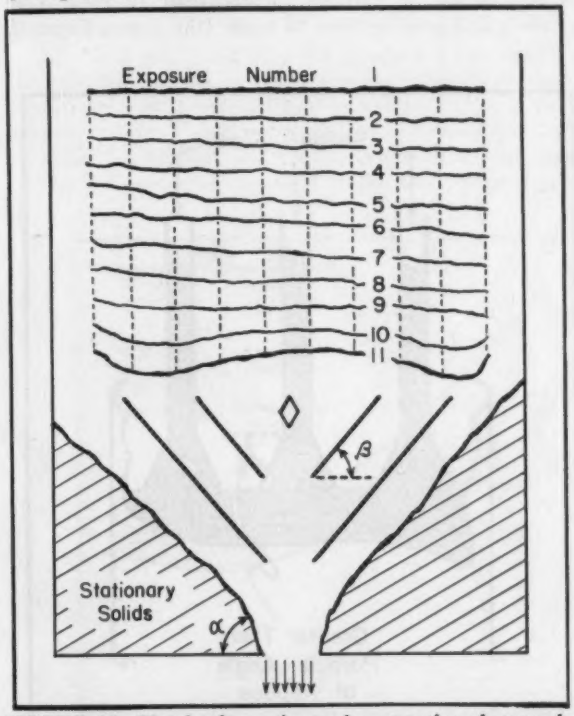

FIGURE 10—Sketch of superimposed consecutive photographs of discharge from baffled bin showing solids, flow paths and profiles. The baffles were sloped at the drain angle of repose, were kept horizontal at the top, and had a constant solids discharge open area.

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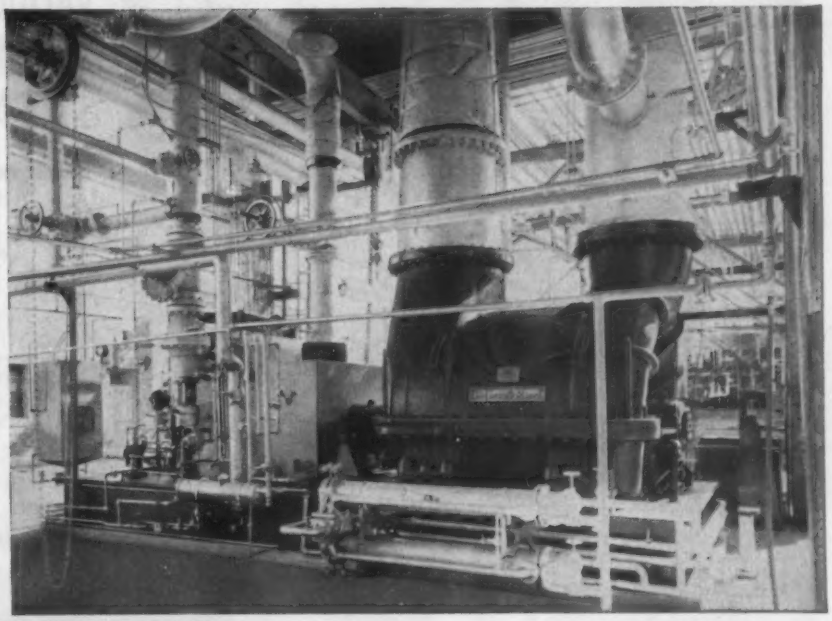
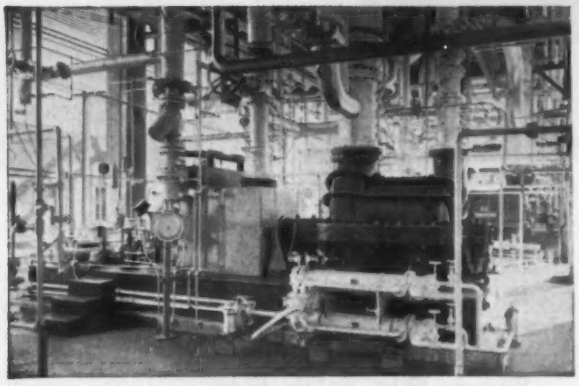
Part 8 in this series will appear in an early issue of PETROLEUM REFINER

at Imperial Oil's new cat cracking plant...

Main air, cat gas and control air —all handled by Ingersoll-Rand centrifugals



At their Halifax gasoline-fuel oil refinery, Imperial Oil Limited recently installed five completely new process units, including a fluid-catalytic cracking plant with a capacity of 13,800 barrels per day (fresh feed). This modern unit, designed and constructed by Foster Wheeler, Ltd., converts light and heavy gas oil fractions into high octane gasoline, valuable gases and, if required, heavy cycle oil for fuel oil blending.



Main air blower for the cat-cracking unit is a 50,500-cfm capacity Ingersoll-Rand centrifugal driven by a 3600-hp I-R multi-stage, multi-valve steam turbine. The blower operates at 3500 rpm and delivers air at 30 psia.

Cat gas compressor has a capacity of 10,200 cfm. It is a 2300-hp, 6600-rpm unit with discharge pressure of 120 psia. Like the main air blower, it is driven by an I-R turbine operating at steam conditions of 580 psig, 700° F.T.T., 130 psig back pressure.

THIS installation of I-R centrifugals, which also includes a 5050-cfm capacity control air blower, is typical of Ingersoll-Rand's ability to provide all the air- and gas-handling equipment for any catalytic cracking process. Every I-R centrifugal is designed and built for maximum dependability and long-range economy in the particular service for which it is intended. When expansion or modernization involves new air- and gas-handling equipment, be sure to consult your Ingersoll-Rand representative. 12-634

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One of the largest refinery projects in terms of diversity of facilities is the $50 million expansion program presently under way at Petroleo Brazileiro's Mataripe refinery. A complete description of this program plus a list of some of the unique features which are being incorporated into the refinery are presented for your information in this month's "Who's Building."

Keep Going to Page 183

Amoco's Closing

A great portion of this month's "What's Happening in the Industry" is devoted to giving you the full story on why Amoco Chemicals closed its Brownsville, Texas plant. We have presented a history of the plant, and a complete description of all of the problems mechanical and otherwise which beset the plant since Pan American Petroleum bought it in March, 1954. It makes for both interesting and informative reading so be sure that you . . .

Keep Going to Page 241

Equipment News

Exactly 30 items of new equipment and literature are ready to help keep you informed as to "What's New in Equipment and Manufacturers Literature."

Keep Going to Page 339

"BOXSCORE" Prelude

This month, PETROLEUM REFINER again presents its quarterly feature, "Construction BOXSCORE," a tabulation of refinery, petrochemical, and natural gasoline construction projects from all over the world. Preceding the tabulation, however, is a story presenting the results of a recent PETROLEUM REFINER staff research problem which compares the rise in octane numbers in different sections of the country with the increase in reforming capacity. We were very interested in the results—and we're sure that you will be too.

Keep Going to Page 172

Mosquito Hint

Bet you didn't know that the following little poem (describing a mosquito's action) can help you construct a piece of logarithmic paper.

Blithely light, lightly light,
Take one tasty bite.
It can—and you'll find out how if you . . .

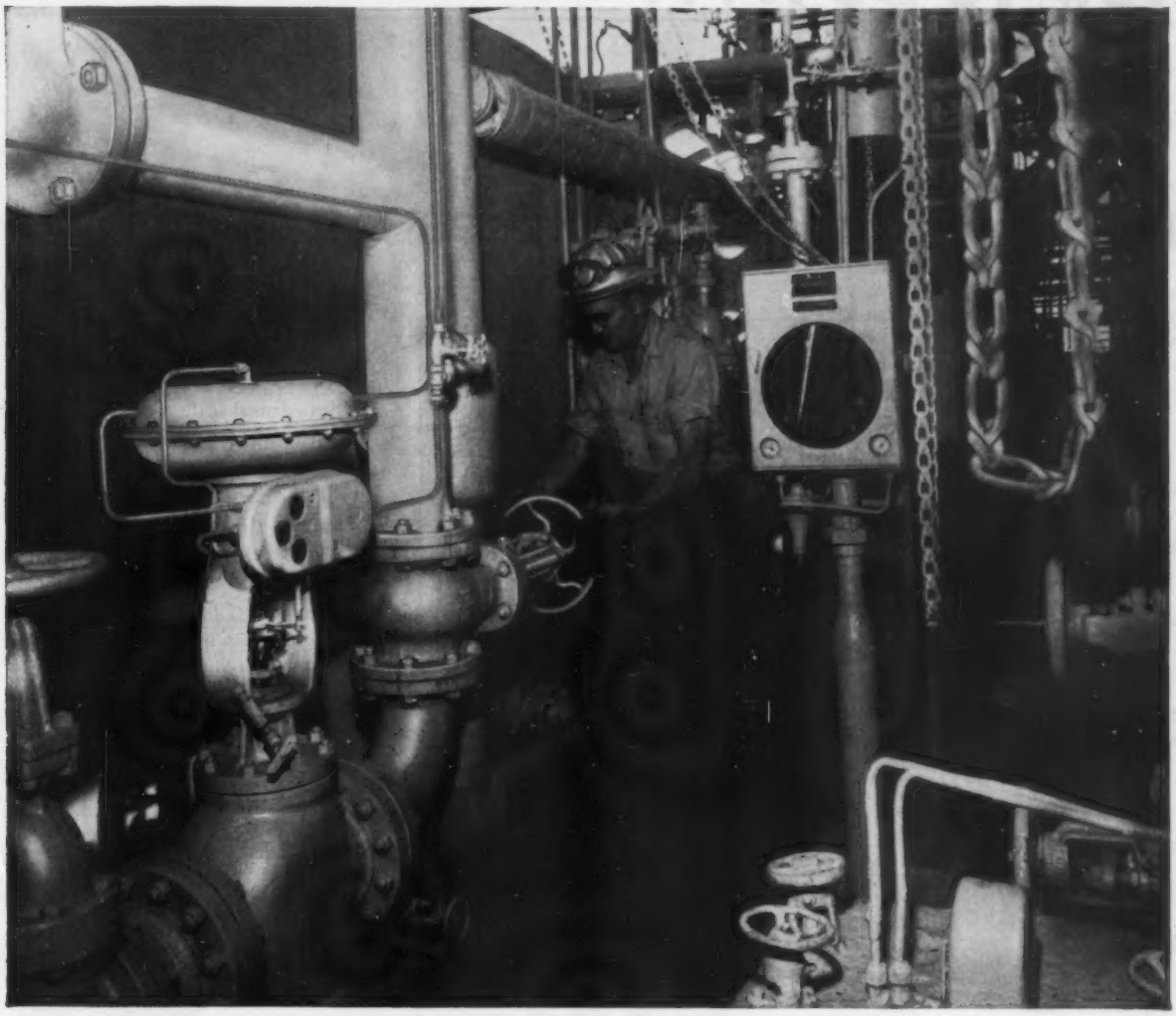
Keep Going to Page 174

News Flashes!

What country claims to have transformed gasoline into a solid? You'll know after you read "Changing Times," that fast-moving account of those items that made the news last month.

Keep Going to Page 258

Refinery proves economy of CRANE Steel Gate Valves



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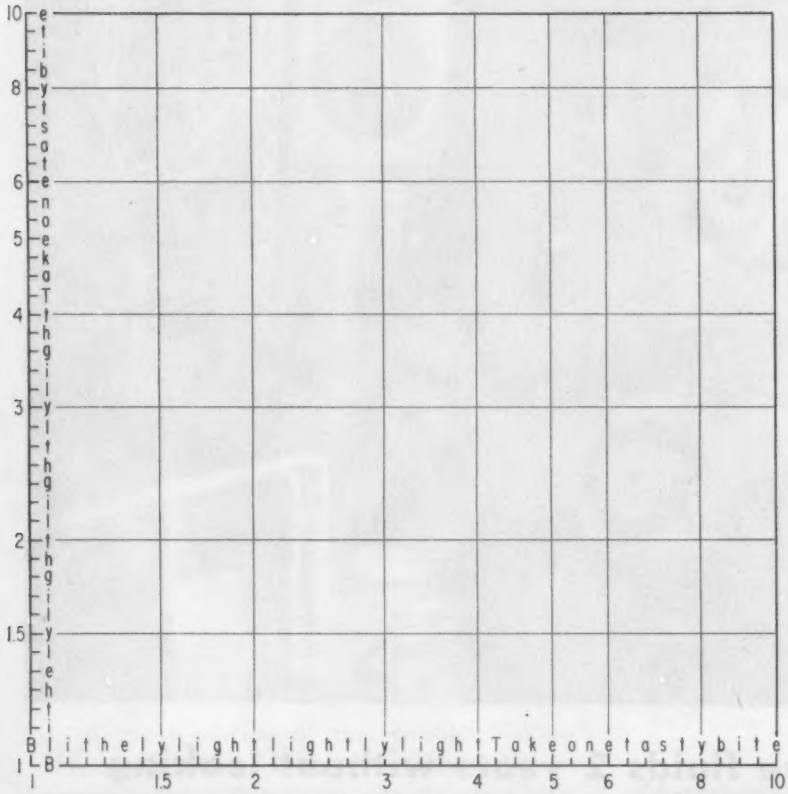

Every engineer, at some time or other, has the need for a piece of logarithmic paper with nothing available but natural scale paper.

Logarithmic paper can be constructed from natural-scale paper without the use of tables of logarithms by means of the following "mosquito" method. Merely keep in mind the little rhyme:

Blithely light, lightly light;
Take one tasty bite.

Horizontally and vertically from the origin on natural-scale paper write out the rhyme, omitting spacing and punctuation, with one letter to a division as shown in the figure. Mark successively the numbers 1.5, 2, 3, 4, 5, 6, 8, and 10 at the last letters of the words. Then draw the horizontal and vertical rulings to complete construction of the logarithmic paper. This approximation is good to about one-third of one percent.

Idea submitted by:
Dr. D. S. Davis
University of Alabama

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Standard's Whiting refinery had a problem—how to move a 60,000 barrel water tank to make room for a new reformer unit.

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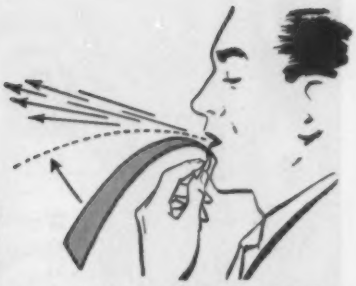
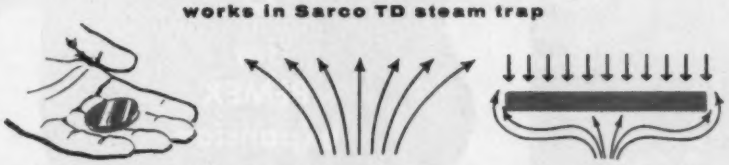


THE PAPER EXPERIMENT

Hold a strip of paper (about 1⅜" wide by 7" long) directly under your lower lip. Blow — creating **low-pressure** area above the paper. It will be forced **upward** by atmospheric pressure, rising to horizontal position!

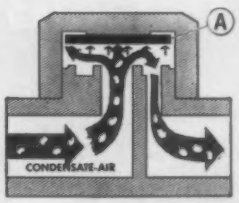
SO SIMPLE—this is way same principle works in Sarco TD steam trap



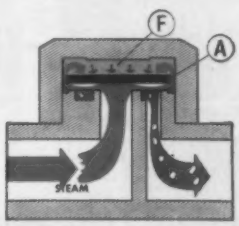
1. Substitute a simple Sarco valve disc for the strip of paper.

2. Substitute a high velocity jet of steam for the jet of air.

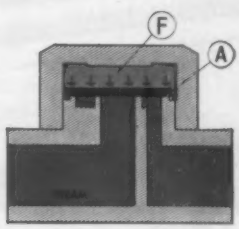
3. Direct steam jet across bottom of Sarco valve disc. This creates **low-pressure** area under disc—resulting in **downward** valve-closing force.



A. Inlet pressure raises disc "A" from seat . . . immediate discharge of air and condensate.

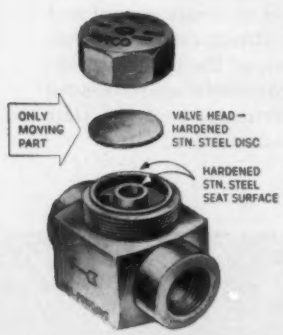


B. Steam follows condensate and the high velocity jet across bottom of disc "A" creates low pressure area (Bernoulli effect) . . . jet is deflected into chamber "F" where it builds up pressure by recompression and this pressure acts on top of disc "A" . . .



C. Pressure in chamber "F", acting on full top area of disc "A", exceeds force of incoming steam and low pressure area under disc . . . and immediately forces it down, closing inlet. As condensation decreases pressure in chamber "F", disc rises and steps **A** or **B** repeat.

No other steam trap like it! The Sarco TD embodies the most important advance in steam trap design in years . . . the thermodynamic principle. Introduced in 1953, the Sarco TD has been thoroughly service-proven. Thousands have been installed . . . are providing a level of trapping efficiency and economy heretofore unobtainable.



Small size . . . large capacity

Only 3 parts . . . all stainless steel. Sizes ⅜ to 1"—each body is as small as a tee fitting! Capacity is determined not by a bulky body but by the effective orifice, valve action, pressure drop and condensate temperature.

A FEW OF MANY ADVANTAGES

- *Practically no maintenance*—no valve mechanism, no narrow channels. Trouble-free, simple design.
- *Cuts trap inventory*—one large capacity seat for all pressures . . . for heavy, light or no condensate load.
- *Self-adjusting for pressures 10 to 600 psi*—not a single change or adjustment required.
- *Operates perfectly when pressure fluctuates*—throughout full pressure range.

See for Yourself

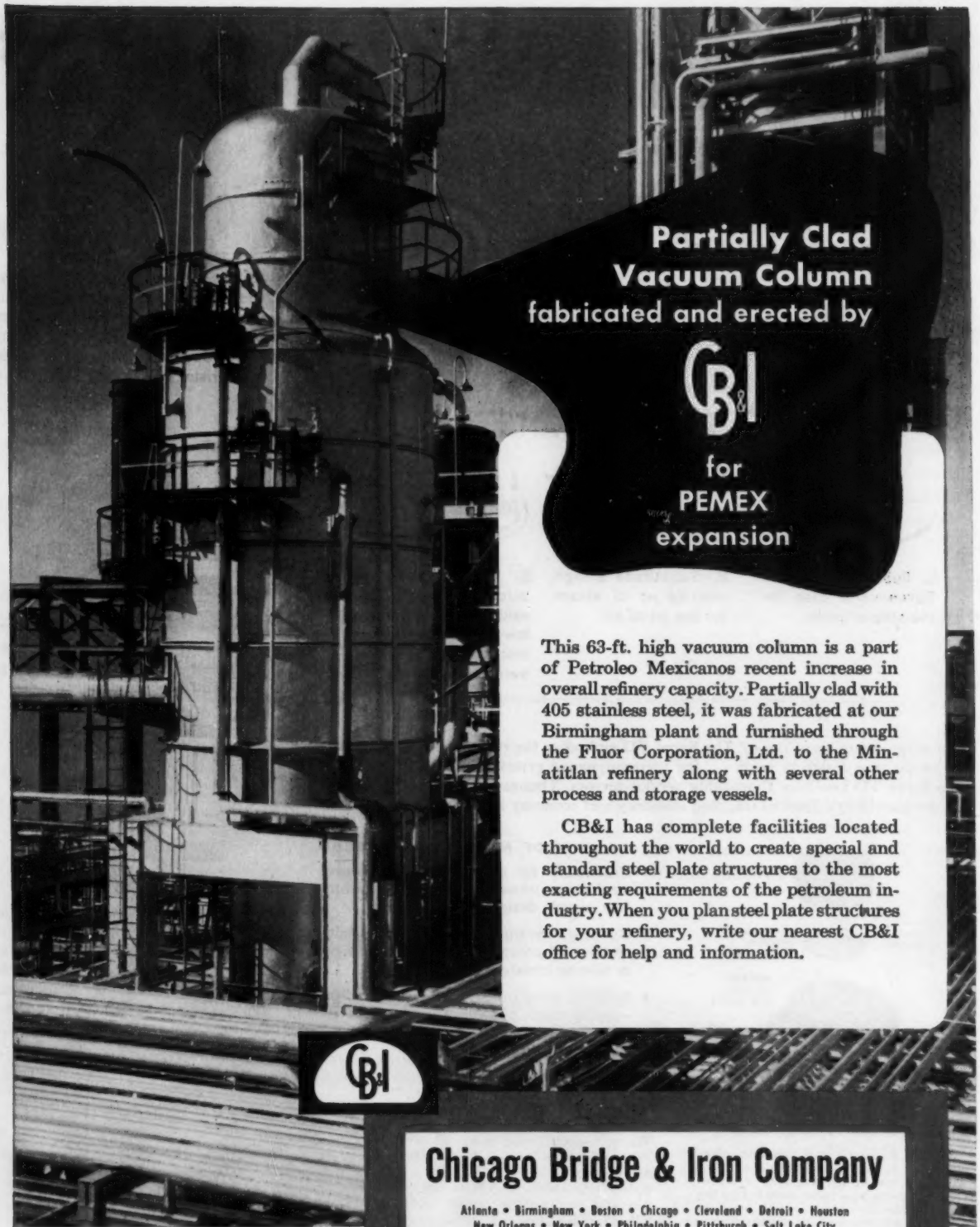
We will gladly send you a Sarco TD Steam Trap and strainer for 60-day trial. No cost or obligation. You buy the TD *only* if you're completely satisfied. Advise size—⅜, ½, ¾ or 1"—and application. Sarco Company, Inc., 635 Madison Avenue, New York 22, N. Y.

2205-C

SARCO Thermo-Dynamic STEAM TRAP

THE MODERN TRAP THAT IS MAKING STEAM TRAPPING HISTORY!

For more data on advertised products, use Readers' Service Cards, last page.



Partially Clad Vacuum Column fabricated and erected by CB&I for PEMEX expansion

This 63-ft. high vacuum column is a part of Petroleo Mexicanos recent increase in overall refinery capacity. Partially clad with 405 stainless steel, it was fabricated at our Birmingham plant and furnished through the Fluor Corporation, Ltd. to the Minatitlan refinery along with several other process and storage vessels.

CB&I has complete facilities located throughout the world to create special and standard steel plate structures to the most exacting requirements of the petroleum industry. When you plan steel plate structures for your refinery, write our nearest CB&I office for help and information.

Above: 63-ft. high vacuum column partially clad with 405 stainless steel built by CB&I for Petroleo Mexicanos Minatitlan refinery.

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
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Horton Steel Works Limited, Toronto; Chicago Bridge & Iron Company Ltd., Caracas; Chicago Bridge Limited, London; Sociedade Chibridge de Construcoes Ltda., Rio de Janeiro.

up with the idea of calling in a local housemoving firm. When they came out of their huddle, plans were laid to move the tank just as if it were a house.

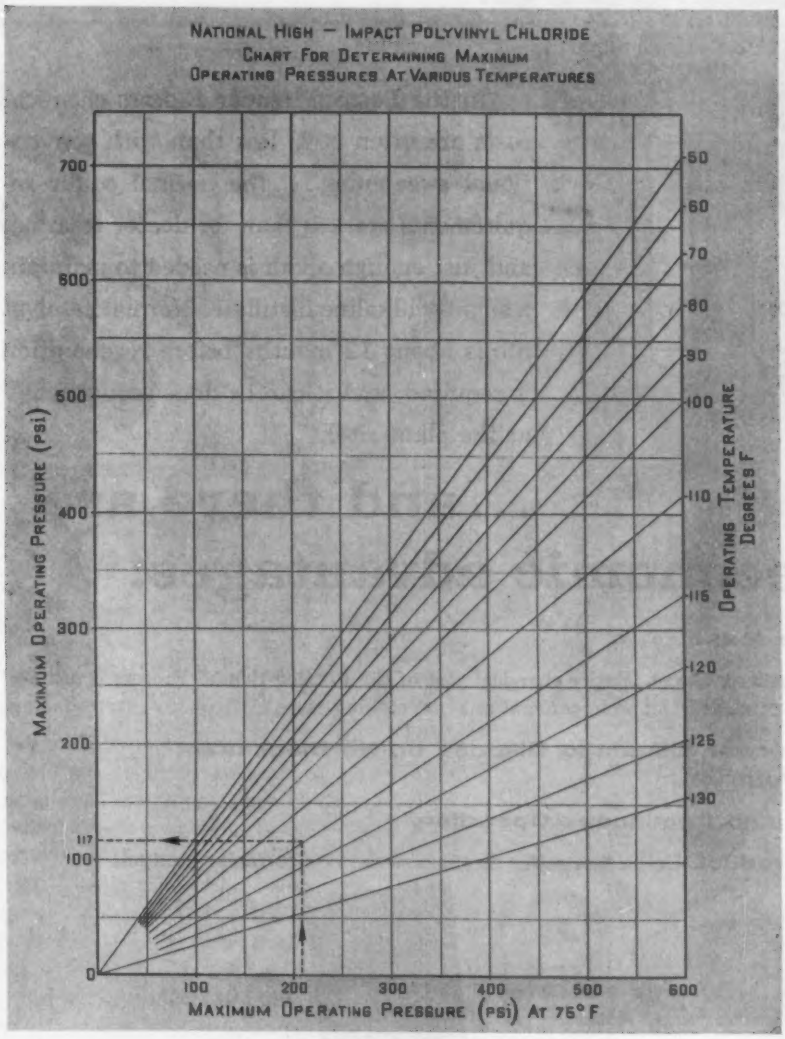
They chipped away the foundation, and jacked up the tank. Supporting the sagging tank bottom with heavy beams, they rolled dollies under it. And away they went.

Some 800 feet later the peripatetic tank came to rest, but only after three stops to change direction and a constant battle against soft sand and heavy winds.

It was estimated that the house-moving-type tank-moving cut the disassemble-reassemble method's time in half, and cut the cost almost two-thirds.

Photograph and story courtesy *The Standard Torch.*

How to Do It . . .



Graph Shows PVC Pipe Limiting Conditions

Polyvinyl chloride pipe can be employed up to 130 F. in the case of high impact and up to 150 F. in the case of normal impact. Creep considerations at higher temperatures result in excessive derating of the recommended pressures above these points. The chart presents adjustment factors to be applied to 75 F. ratings for service at higher temperatures for high-impact materials. The recommended pressures at the higher temperatures are based on creep data and assume an allowable expansion over

Here's proof

Superior quality forged body —precision machined
Uniform wall thickness —no weak spots
Extra heavy reinforcing rim
Larger diameter cam ears for longer service life
Extra Hi-Strength forged handles —greater economy
Stainless Steel pins —greater safety and longer service
Uniform heavy wall thickness —no weak spots
Recess retains gasket in coupler and assures proper placement
Superior quality forged body —precision machined —accurate tolerances

your best buy is EVER-TITE -the best quality quick couplings

Bronze
Aluminum
Stainless
Carbon
Malleable
Hastelloy

You save time and money when you use EVER-TITE COUPLINGS, because you get speedy deliveries—no leaks.

The tightness is predetermined in manufacture so you can be *sure* with EVER-TITE.

The EVER-TITE trademark is a hallmark of dependability. EVER-TITES do the best job in the transfer of every type of product through hose or pipe.

Get EVER-TITE and get the *best*. Ask your distributor now.

EVER-TITE COUPLING CO. INC.
254 West 54th Street
New York 19, N. Y.

Every EVER-TITE saves time and money

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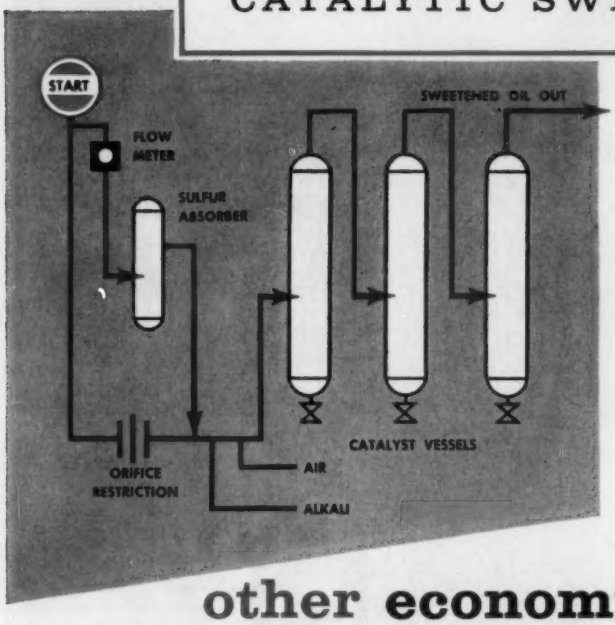
only 20% of the operating costs of conventional doctor treating!

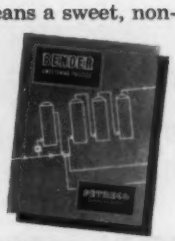
PETRECO-BENDER
CATALYTIC SWEETENING PROCESS



In the Petreco-Bender Process chemical costs are often 80% less than with conventional sweetening . . . the normal sulfur requirements are less than for doctor treating, and just enough alkali is needed to maintain a slightly alkaline distillate. Normal catalyst life is about 12 months before regeneration is required, and it can be done economically at the plant site.

. . . and there are other economic advantages:

- **No volume loss.**
- **Low Operating Cost.** Entire chemical cost of the Petreco-Bender Process is often less than cost of utilities alone in conventional sweetening.
- **No Regenerator Effluent to Dispose of; No Blackstrap; No Air Pollution.**
- **Automatic and Continuous Operation.**
- **A Better Product.** Use of less sulfur means a sweet, non-corrosive product.



FREE ILLUSTRATED BULLETIN
. . . Available to you on request.

PETRECO

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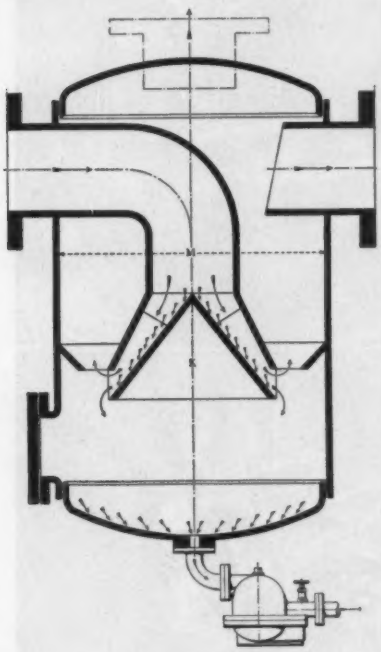
B-57-2

the life of the installation. From an ASME paper entitled "Plastic Pipe in the Petroleum Industry," by George C. Anderson, National Tube division, United States Steel Corp., presented to the Petroleum division meeting in Tulsa, September 22, 1957.



Make Yourself a Separator For Drying Air and Gases

In every refinery are pressure vessels thrown on the scrap heap, which are in good condition. Some of these welded vessels may be adaptable to make large size separators for air or gases. The principle used to separate liquid droplets is the repulsion cone as shown in the sketch. The cutting and welding jobs can be performed by any skilled welder. Compressed air or gas enters from left, is directed against the repulse cone, where the fluid looses moisture and other particles. The latter slide down the cone towards the opening at the bottom. An air trap with ball float automatically drains the vessel. The dried air or gas leaves the separator on the righthand side. An alternative outlet is shown in dotted line on top of the vessel.

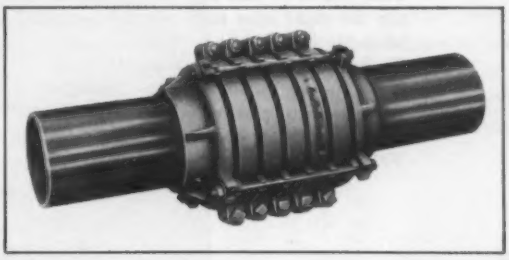
19,862 years of precision metal-forming

Time brings experience . . . experience brings skill . . . and the FLEXON® team of engineers, metallurgists, and technicians have worked a total of **19,862** years perfecting the most skillfully-made expansion joints that can be formed.

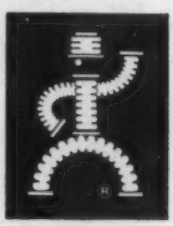
These same skills are part and parcel of all Flexonics formed and corrugated tubular shapes in metal—flexible metal hose, instrument-type bellows, "impossible" bends and section modulations for aircraft parts. They assure you expansion joints that you can **install and forget.**

Always specify FLEXON Expansion Joints—free-flexing and controlled-flexing; dual and multiple types; balanced joints and other special designs; all in stainless steel, monel, and other workable alloys. Flexon Expansion Joints last longer on the job—because they are engineered right and made better.

Write today for your copy of the Flexon Expansion Joint Design Guide—28 pages of facts about absorbing pipe motion.



EJ-208

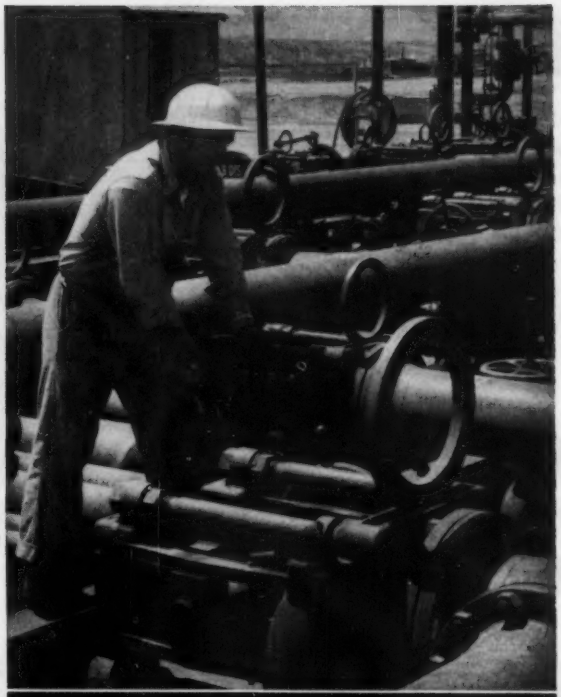


Flexonics
corporation

EXPANSION JOINT DIVISION— 1336 S. THIRD AVE., MAYWOOD, ILL.

EXPANSION JOINTS | METAL HOSE | NON-METALLIC HOSE | BELLOWS | AIRCRAFT COMPONENTS

For more data on advertised products, use Readers' Service Cards, last page.



keep hard-to-hold fluids in hand with Hamer Valves!

When the service conditions are tough and a lot is riding on the valves performance, play it safe, specify and install a Hamer Valve.
Why a Hamer Valve? The reason is simply proven dependable performance ... a performance that has measured up time and time again under some of the most crucial service conditions to which any valve has ever been subjected.
Why are Hamer Valves so outstanding? We feel it is because of the extra measure of effort given to their design and manufacture. Hamer Valves are made slowly, carefully. Each valve part is individually inspected, each valve individually tested, each customer order analyzed to be sure the valves ordered are the right ones to do the job expected of it. Nothing is left to chance or guess. To be sure, you will pay a little more for a Hamer Valve. But the unmatched performance, makes the additional cost well worth it for these fine Hamer Valves, truly a valve without equal.

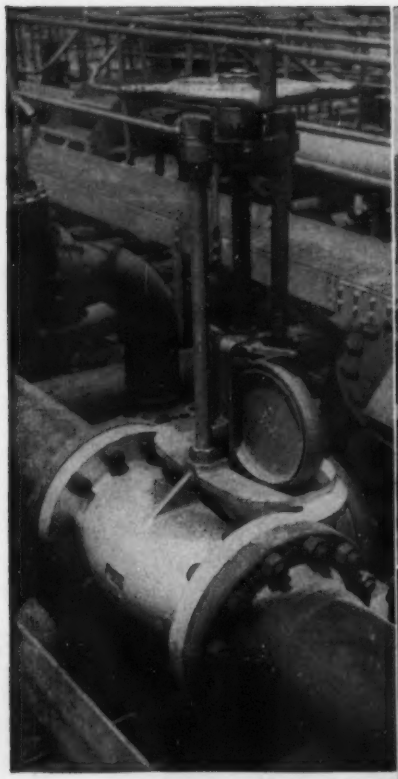
HAMER LINE BLIND VALVES

No contamination allowed here...

World-wide usage of the Hamer Line Blind for over two decades where absolute blanking of a line is required, is proof positive of this valve's effectiveness.
In addition, these remarkable valves will actually pay for themselves through savings gained by fast one man, one minute operation, elimination of complicated piping and costly downtime.

Hamer VALVES, Inc.

P.O. BOX 1851, 2919 GARDENIA AVE., LONG BEACH, CALIF.
REPRESENTATIVES THROUGHOUT THE WORLD



HAMER VISIBLE WEDGE

Foolproof line shut-off

A new high in safety, stability and simplicity of operation is incorporated in this outstanding rigid-type Visible Wedge Blind Valve. Precision metal-to-metal fit of the wedge and seats, plus dependable seal rings, provides a foolproof line shut-off that's both positive and permanent.

HAMER GATE VALVES

Leakproof Shutoff, Upstream, Downstream...

This remarkable valve combines a double sealing action through its metal to metal fit of the wedge plus two Teflon* seal rings. Actually one Hamer Gate Valve will do the job which formerly required two Gates for a double block and bleed arrangement. In addition, the wedge guide is precision machined to exacting tolerances. Eliminates chatter and mechanical wear caused by line pulsation and accurately centralizes the wedge between the seats.

*R. TM Dupont

HAMER PLUG VALVES

This Lift-Type Plug can't stick ever!

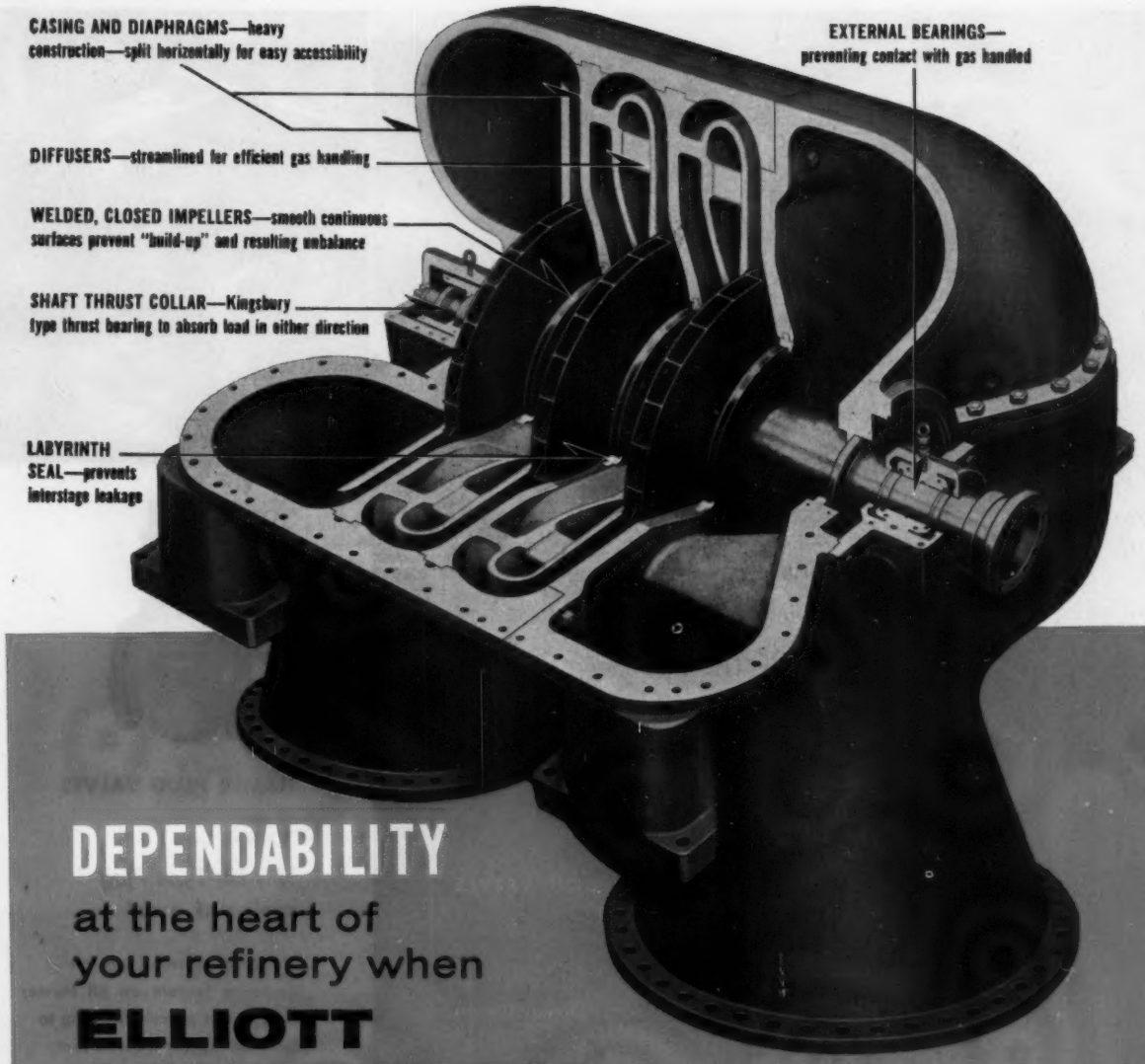
The plug adjusting nut, an exclusive feature on all Hamer Plug Valves permits the plug to be lifted slightly from its seat, making it easy to open or close the valve. A simple turn lowers the plug back into its seat and holds it there in perfect alignment. No matter what the service conditions, or lapse of time between operations, this outstanding Hamer feature assures POSITIVE E-Z Turn control of the plug at all times.

Send for Free Literature

Bulletins on all Hamer Valves are available and will be sent upon request

HAMER "POSITIVE ACTION" VALVES

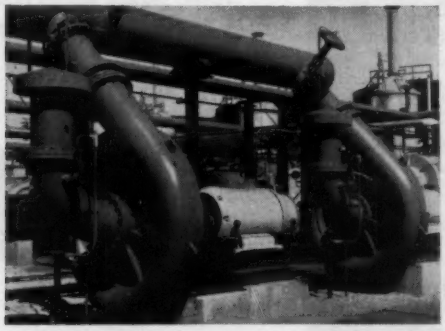
For more data on advertised products, use Readers' Service Cards, last page.


CASING AND DIAPHRAGMS—heavy construction—split horizontally for easy accessibility
EXTERNAL BEARINGS—preventing contact with gas handled
DIFFUSERS—streamlined for efficient gas handling
WELDED, CLOSED IMPELLERS—smooth continuous surfaces prevent "build-up" and resulting unbalance
SHAFT THRUST COLLAR—Kingsbury type thrust bearing to absorb load in either direction
LABYRINTH SEAL—prevents interstage leakage

DEPENDABILITY

at the heart of
your refinery when

ELLIOTT CENTRIFUGAL COMPRESSORS are in service!



Two of three Elliott motor-driven single-stage centrifugal compressors serving oil black plants in Oklahoma. Each compressor is rated 5255 inlet cfm, handling air at atmospheric pressure and boosting it to 3.85 psig.

Elliott centrifugal compressors are designed and built with the simplicity and ruggedness that pays off in *dependable*, long-term, non-stop performance. Available in single and multistage types . . . for inlet capacities up to 150,000 cfm and pressures up to about 500 psig equivalent air pressure . . . turbine or motor driven . . . with or without step-up gear. For further details, call your nearby Elliott District Office or write Elliott Company, Compressor Department, Jeannette, Pa.

ELLIOTT Company

P7-3

For more data on advertised products, use Readers' Service Cards, last page.

Who's Building . . .

Construction BOXSCORE appears On Page 197

$50 Million to Expand Brazilian Plant

Highly diversified refinery will include 13 new units and complete offsite facilities.

(This lead story for the "Who's Building" section was prepared and written for PETROLEUM REFINER *by M. H. Norlander, project manager for The M. W. Kellogg Co.)*

ONE OF THE LARGEST refinery projects in terms of diversity of facilities being constructed is the $50 million expansion program presently under way at the Petroleo Brasileiro S. A.'s (Brazilian Government owned corporation) Mataripe Refinery near Salvador, Bahia, Brazil. This project will include thirteen process units, complete refinery offsite facilities and a separate marine terminal. The M. W. Kellogg Co., New York, and its subsidiary, Companhia Kellogg Brasileira, Rio de Janeiro, are designing and enginering this expansion and Kellogg Pan American Corp. is providing erection and operating supervision.

A complex project, no interruption in the flow of products from the refinery could be tolerated even though the area occupied by some of the existing offsites will be used for erection of new process units. By changing application of the existing units, many of the present offsite items will be used in different services at new locations in the expanded refinery.

The marine terminal is located on an island approximately five miles from the refinery and, except for electric power which is furnished by the refinery, is a complete entity. The power cables and the product lines are being routed overland through almost uninhabited jungle. One special feature in the design of these facilities was the design and erection on a "crash program" basis of facilities to permit offshore loading of crude into T-2 tankers. This program was completed and in operation in approximately six months after the "go-ahead" was received.

This current expansion is the second for the Mataripe refinery. The original plant, which went on stream in 1950, contained units for crude distillation, gas oil cracking, visbreaking and naphtha reforming. These units were integrated on a single plot as a combination unit. The rated crude charge was 2500 bpd. Because of its location, this plant had to be self-sufficient with respect to utilities, hence, the offsites include steam and power generation, salt water pumping station, marine loading station as well as the usual tankage, pumping, blending facilities and the like. Petrobras erected and maintains its own village for personnel.

The first expansion, which increased crude running capacity by 2500 bpd, went on stream in 1953. Process facilities consisted of:

1. A new combination unit similar to the original unit except that a vacuum flashing stage and additional gas recovery equipment were added;
2. A new Catalytic Polymerization unit.
3. Revisions to the existing combination unit to improve gas recovery.
4. Addition of offsite facilities as necessitated by the above process units.

The expanded refinery at the completion of the current project will include the following process units:

1. Two separate 7500 bpd crude distillation units. These units will be made by revising the two existing combination units.
2. A 22,000 bpd atmospheric & vacuum crude distillation unit de-

Special Features

The refinery incorporates these unique features some of which are "firsts" for the area:

1. The greatest number of process units ever designed and engineered simultaneously for a South American refinery.
2. The first units built in Brazil using solvent extraction and treating methods for the production of lube oils.
3. The first Orthoflow catalytic cracking unit built in Brazil.
4. The first centrifugal extractor installed in Brazil for separating phenol-oil mixtures.
5. The first plant for producing wax products from petroleum sources.
6. The first large scale plant designed to operate with Brazilian crude as a charge stock.
7. A substantial amount of Brazilian manufactured equipment including pumps, motors, pipe and fittings, structural steel as well as all common building materials will be used.
8. Materials and equipment from three countries other than Brazil will be used.

signed to handle Brazilian or medium sulfur Near-East crudes.

3. An 18,000 bpd (total feed) Orthoflow Catalytic Cracking unit with extensive gas recovery facilities.

4. A 180 bpd butylene catalytic polymerization unit. This unit is a revision of the existing catalytic polymerization facilities.

5. A 500 bpd catalytic polymerization unit.

6. An 8500 bpd vacuum distillation unit designed to produce lubricating oil base stocks.

7. A 6300 bpd (nominal capacity) phenol extraction unit designed to use a centrifugal extractor rather than the conventional counter-current flow tower.

8. A 3600 bpd (nominal capacity) propane deasphalting unit.

9. A 3700 bpd (nominal capacity) propane dewaxing & deoiling unit.

10. An 1870 bpd (nominal capacity) wax distillation unit.

11. A 2800 bpd (nominal capacity) wax & oil percolation unit.

12. A plant for the manufacture of wax modifier.

In addition to the foregoing units, provision has been made in the plant layout and the utility distribution system to permit the incorporation of a catalytic reforming unit and gasoline and kerosine treating facilities.

Expansion of the offsite facilities in the current program will include:

1. A new power plant in which there will be three 225,000 #/hr, 600#, 750 F TT steam boilers and three 2500 KW, 13,000 volt turbo-generators together with their attendant facilities. After this new power plant is in operation, the original power plant will be dismantled and the three existing low-pressure boilers and their facilities incorporated into the new power plant.

In addition to supplying utilities for the refinery proper, the power plant will supply power for the village and the marine terminal, some five miles distant.

2. A new salt water pumping station including a new intake and flume which will extend 1500 feet out into Bahia Bay. When this new pumping station is put into operation, the existing station will be abandoned and its equipment incorporated into the new station.

The new cooling water effluent system from the refinery will include separators and a holding basin and the effluent will exist through a flume to an estuary on the opposite side of the peninsula from the intake. The existing effluent system will be kept in service but a holding basin will be added to minimize outflow problems when usually high tides occur.

3. Reuse of existing tankage but in services different from their present service and, generally, in different locations. Refinery product tankage is limited to run-down and intermediate storage and final storage is located at the marine terminal. Crude storage for refinery operations is located at the refinery and the marine terminal contains storage facilities for receipt from tankers of imported crudes.

4. The usual pumping equipment for handling refinery internal distribution plus a separate pumping station for transferring products from the refinery to the marine terminal.

5. Wax handling facilities which will permit either bulk distribution or distribution in cartons.

6. A truck loading station for distribution of locally used products.

7. New or enlarged administrative, laboratory, maintenance and similar facilities.

The marine terminal, located on an island, is a complete entity except for power generation. Product storage is provided for gasoline, kerosine, fuel oil, four lube oil stocks, propane LPG and butane LPG. Pumping equipment is provided for loading tankers, coastal vessels and barges.

The docks, which are being furnished by Petrobras but for which Kellogg and Companhia Kellogg Brasileira are designing the piping and other facilities, presently contemplate separate berthing piers for two T-2 or larger tankers, a berthing pier for smaller coastal vessels and two berthing points for barges.

Erection of the refinery facilities and marine terminal is presently under way and is scheduled for completion in 1959. Erection supervisors have been furnished by Kellogg Pan American Corp.

Operating supervisors also will be furnished by Kellogg Pan American Corp.

Gulf Oil Corp. has awarded a contract to Procon, Inc., to install facilities to process approximately 10,000 bpd of light gasoline at its Port Arthur, Texas refinery.

The facilities will include fractionation equipment and a pentane isomerization unit. The hydroisomerization process employed is based on developments in the laboratories of both Gulf Research and Development Co. and Universal Oil Products Co. It is believed that this will be the first commercial unit to use a platinum catalyst for isomerizing pentanes.

The new facilities will produce three main products: isopentane for use as a high quality blending stock in aviation and premium motor fuels; a dehexanized product which will be charged to a 26,000-bpd Platforming unit where this material will be upgraded into a high quality motor fuel; and hexanes for use as a starting point for certain chemicals.

Standard Oil Co. (Ohio) has broken ground for its new $3.8 million alkylation unit at its Cleveland No. 1 refinery. The unit is to be completed May 1, 1958, and so rigid is the building schedule of Arthur G. McKee & Co. of Cleveland, who have the prime construction contract, that the brief ceremonies were conducted despite a drizzling rainfall.

The new unit is an advanced version of the alkylation unit which was built at the Sohio refinery in Toledo in 1953 and is used to produce high octane aviation gasoline.

The feed stock will be butane gases from the Cleveland refinery catalytic cracking operation which will be converted with sulphuric acid catalytic to 100-plus high-octane gasoline blending stock.

The maximum feed rate to the new alkylation unit will be 230,000 gallons per day with a product maximum of 150,000 gallons per day of 100-plus octane gasoline components.

Frontier Refining Co. will increase the capacity of its Cheyene refinery from 16,500 bpd to 22,000 bpd. The company is also doubling the capacity of the plant's asphalt unit to 10,000 bpd. The expansion is being financed through a $1.5 million loan from the Metropolitan Life Insurance Co.

Commerce Oil Refining Corp. has awarded The Fluor Corp., Ltd., a contract in excess of $50 million to design, engineer, and construct a complete 43,000 bpd refinery at Jamestown, R. I.

The installation will cover a 600-acre site on the northern end of Conanicut Island, located in Narragansett Bay, near Providence.

Designed primarily to produce high octane gasoline, the refinery will employ the latest processes including: pentane isomerization, Unifining, Platforming, alkylation and catalytic cracking. Pollution of the air by undesirable sulfur compounds present in the crude oil will be prevented by converting the harmful compounds into sulfur which will be sold to chemical manufacturers.

More than 60 percent of its production will be 100 plus octane gasoline, the remainder distillate fuel oils and miscellaneous products.

Offsite facilities will include a 600,000 pounds-per-hour boiler plant, a complete salt water cooling system, tank farm, docks for loading tankers and other facilities.

Fluor has started engineering work on the project and construction is scheduled to begin soon, with completion set for early summer, 1959.

Petroleos Mexicanos plans to increase refining capacity in Mexico by about 100,000 barrels daily by late 1958. If carried through, this program would satisfy mounting demands in 1957 and 1958 and displace about 50,000 bpd of products being imported. Many industries have reportedly expressed willingness to pay higher petroleum product prices to Pemex if they can be assured plentiful domestic supplies. The government is expected to announce a new schedule of higher product prices soon.

From two to four additional refining units are to be completed within the next two years, according to *Noticias*.

The California Oil Co. has announced that construction work is underway at Perth Amboy (N. J.) on new process equipment designed to increase production of the higher octane gasolines, and to manufacture an important petrochemical.

Raised into place at Caloil's Perth Amboy refinery was the first of two tall new towers, one as high as a 17-story building, which will re-distill gasoline to produce an even greater quantity of top octane fuel. At the same time the new units will manufacture normal hexane, which will be treated to make a top-quality commercial solvent.

One of the new towers put into place reaches to a height of more than 200 feet. It is ten feet in diameter, and weighs 120 tons. The other, of a comparable diameter, is 163 feet tall.

Design capacity of the new units is 9700 bpd. Process design work was done by Caloil affiliate, California Research Corp., with the construction contract awarded to the M. W. Kellogg Co., New York. The new units are scheduled for completion by the end of the year.

The Dow Chemical Co. has awarded an estimated $4.5 million portion of its Louisiana division chemical plant construction contracts to Procon Inc., Des Plaines, Ill. Overall, the Louisiana division development involves a Dow investment in excess of $50 million.

Procon's contract covers water and sewerage treatment facilities, plant water pumping facilities, offsite piping, and tank

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For a complete description of The Center and how it can help you bridge the gap between laboratory research and successful production, write for the 16-page brochure "Lummus Engineering Development Center." Address The Lummus Company, 385 Madison Avenue, New York 17, New York.

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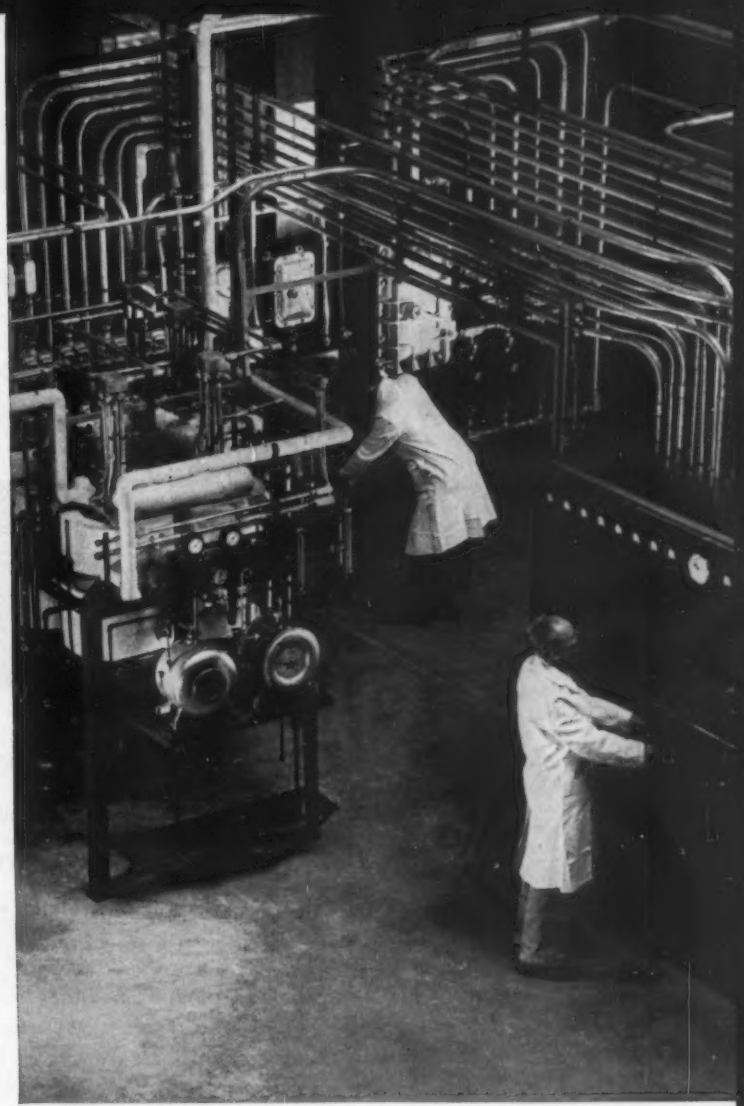
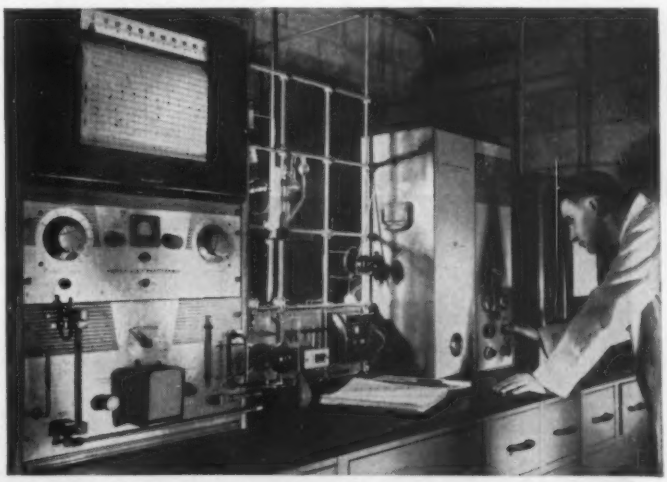


MOST PILOT UNITS at The Center are put together from standard "building blocks." Skid-mounted charging units such as the one at left hold tanks, heaters and pumps for transfer and metering. Process equipment, here shown in background center, can be widely varied. At right is electrical control cabinet. All switches, relays and controls not housed in explosion-proof boxes are enclosed in cabinets like this one, pressurized with outside air to exclude process vapors.



ANALYSIS OF MATERIALS processed and produced in pilot operations at The Center is an important part of the work carried out by Lummus engineers. Here a laboratory technician determines the composition of a multiple-component gas, using a gas chromatography technique.

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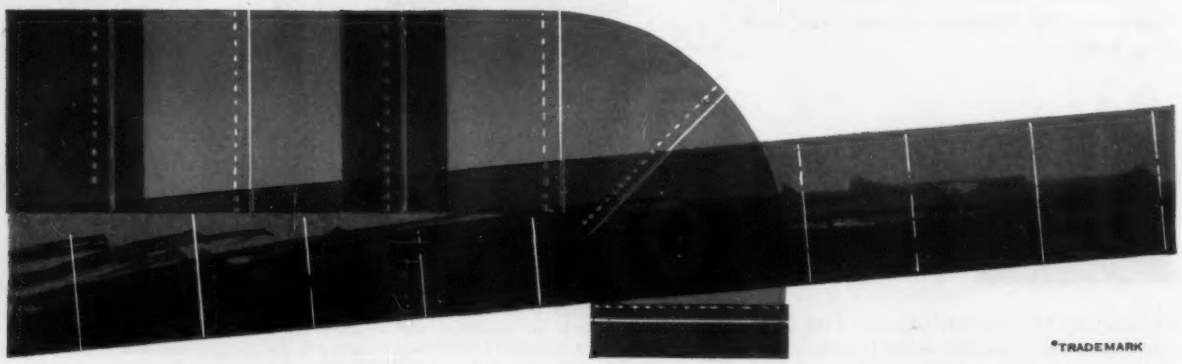

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car cleaning facilities. Completion is expected early in 1958.

The new Dow division will manufacture ethylene and propylene oxides and glycols; chlorinated solvents including carbon tetrachloride, perchloroethylene and trichloroethylene; the plastic monomer, vinyl chloride, hydrochloric acid and caustic soda.

Standard-Vacuum Oil Co.'s long-pending plan for a 25,000-bpd Philippine refinery moved one step closer to realization this month.

The National Economic Council gave its approval for the project after making some modifications in Stanvac's original proposal for a $40 million plant to be established on the east coast of Bataan.

The proposal now goes to the President and the Monetary Board.

Stanvac's plant would be the second in the Philippines. Caltex has a 13,000 bpd plant about 70 miles south of Manila. A Shell affiliate also has had long pending plans to build a refinery in the country.

U. S. Oil & Refining Co.'s 10,000-bpd plant at Tacoma, Wash., is now on stream. A United Transportation Co. barge carrying 30,000 barrels of crude from Canada brought the refinery's first raw material.

Spencer Chemical Co. will build a new urea plant at its Henderson, Ky., works. Completion date for the new plant which will have a daily capacity of about 100 tons is now scheduled for around next summer. Spencer is already producing urea at its Vicksburg, Miss., works.

Dow Chemical Co. has announced that construction of an acrylonitrile plant is scheduled to begin early next year at its Texas division at Freeport.

The new plant, currently planned for completion in December, 1958, is expected to start production during the first quarter of 1959.

Continental Oil Co. has completed a $1.4 million construction project at its Denver refinery, which includes a 3300-bpd catalytic reforming unit.

In addition to gasolines, products from Conoco's Denver refinery include heating oils, diesel fuels, residual fuel oil and propane.

The Denver refinery was originally built in 1931 and was considered the most modern refinery constructed at that time. It later served as a pilot plant for larger units built in the country, and in 1938 its capacity was doubled from 2000 to 4000 barrels daily. Ten years later, a $5.8 million modernization program was completed at the Conoco unit which greatly increased its yield and today the refinery has a daily capacity of 11,000 barrels.

Cities Service Oil Company (Pa), has announced the construction of one of the nation's largest asphalt refineries. The multi-million-dollar manufacturing plant, being built at Linden, N. J., and designed solely for asphalt production is scheduled for completion next year.

The company already refines asphalt at Linden and the new facility under construction adjacent to the present plant will result in a substantial increase in production. The switch-over from old to new

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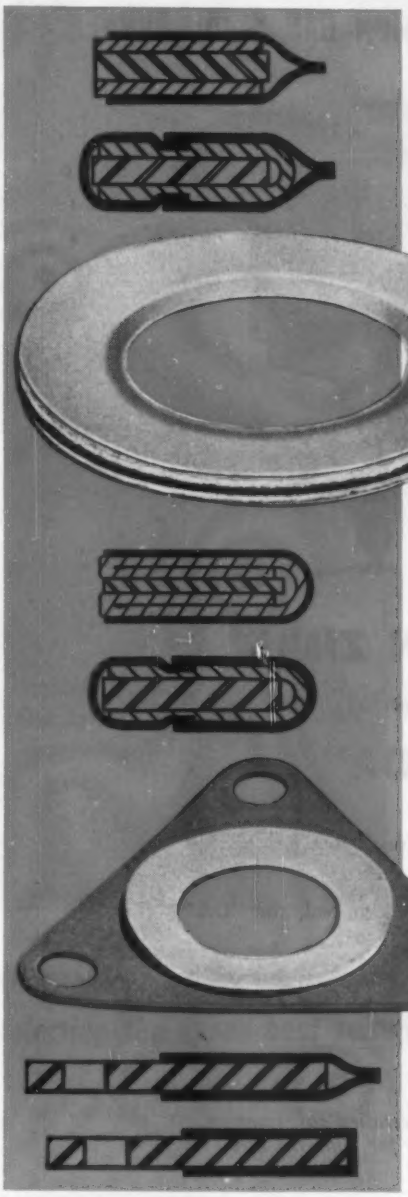

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Illustrated at left is the standard Chemiseal slit-envelope Ring type Gasket designed to fit inside the bolt circle of flanges drilled to 125 lb. standards and made for all standard pipe sizes up to 10" I.D. Stocked for all Pfandler and Glascote standard nozzle sizes from 1½" to 10" I.D.

Also available as shown with double jacket protecting O.D. as well as I.D. against corrosion.

Illustrated at left is Chemiseal formed-shield Ring type Gasket for large diameter glass-lined steel or special material nozzles and irregular shaped openings. Also available as shown with double formed-shield protecting both O.D. and I.D.

Illustrated at left are Chemiseal Gaskets with full face filler with bolt holes, for standard Corning conical flanges. These gaskets seal with unusually low bolt loads. Shown are both slit-envelope and milled-envelope types.

Milled-envelope type fits flush with the pipe I.D. and provides minimum impedance to flow. This type Jacket is supplied either with full face filler or with filler to fit inside bolt circle on standard 125 lb. flanges.

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refinery has been planned to assure no shutdown during construction of the new plant.

The Cities Service facility is located beside the waters of Arthur Kill, which separates Linden from Staten Island. This affords easy access to super-tankers with cargoes of crude petroleum for transformation into arphalt.

Empresa Nacional de Petroles, Chile's government company, may soon start an expansion program at its Concon refinery as the result of a recent announcement of plans for a products pipe line from the refinery to Santiago.

The refinery expansion will add a 24,000 bpd distillation unit at the Concon plant which now has a 20,000 bpd capacity. ENAP also intends to add substantial cracking capacity.

The company last year considered an expansion plan that included the distillation unit, a 9600 bpd vacuum distillation unit, an 11,000 bpd fluid catalytic cracker, a 6000 bpd catalytic reformer, and a 2000 bpd alkylation unit.

The proposed products pipe line will be built jointly by ENAP, Esso Standard Oil Co. (Chile), and Sia. Petroleos de Chile (COPEC), and will run approximately 75 miles to Santiago.

ENAP also has plans for a 44 Mmcfd gas plant and a crude stabilization plant in the Manantiales field on Tierra del Fuego.

Government of India would like to build a plant in the Bombay area to produce 1.5 million tons of fertilizers from tail gases of refineries operated by Burmah-Shell Refineries, Ltd., and Standard Vacuum Refining Co. of India.

Last month the Indian government set up a negotiating committee to talk prices with the two refining companies. If an agreement is reached, India would build a plant to produce 500,000 tons a year of ammonium sulfate and about a million tons of nitrogen fertilizers.

The Texas Co. has announced that Texaco will build a gasoline plant, to process gas from the Aneth Field, in southeastern San Juan County, Utah. The plant will recover and market natural gasoline, butane and propane. Residue gas will be marketed or used for secondary recovery purposes. It is contemplated that other producers in the field will participate in ownership of the plant.

Wiseco Processing Plant, Inc., participated in by Christi, Mitchell & Mitchell Associates and Warren Petroleum Company, will build a natural gas processing plant near Bridgeport, Texas, center of an estimated 2.5 trillion cubic-foot natural gas reserve in the Wise County area of North Texas.

When completed in early 1958, the plant will be a final link in a gathering, processing and transportation system that will deliver the gas from the wellheads in and around Wise County to burner tips in the Chicago area, where an estimated 250,000 consumers await service.

The plant is designed to process 150 million cubic feet per day of gas taken from wells in the Wise County area. From this, the plant would process about 222,000 gallons per day of propane, isobutane,

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Plus factory trained engineers & technicians to assist you in selecting the types best suited to your needs*

There are more than 17,000 items in the Crouse-Hinds line of Condulet® and floodlighting equipment. Each is designed with some specific advantage or quality that makes it best suited for a particular application.

Of course, no engineer, electrician or contractor with a regular job to do, could possibly keep in mind all the pertinent data and information concerning each of these items. That's why Crouse-Hinds maintains a factory-trained field staff of 80 graduate E.E.'s and technical men.

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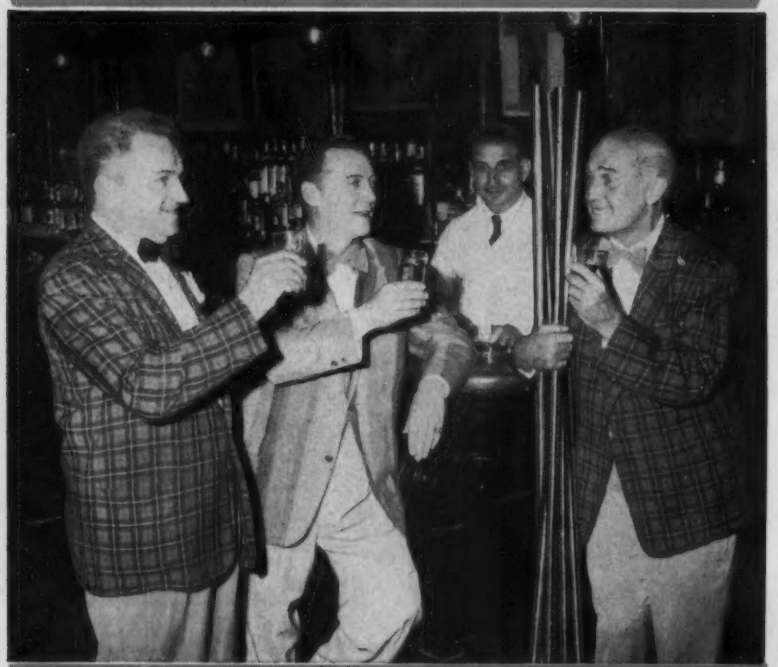
A Bunch of Tubes on a Bender



YOU'RE right — the place is New York's famous Bill's Gay Nineties.

But actually we put our tubes on a slightly different kind of bender and—*presto*—another Heliflow® Coil! Now hundreds of thousands are proving to America's foremost industries Heliflow's outstanding performance. Yes Sir, it all starts with a bunch of tubes on a bender!

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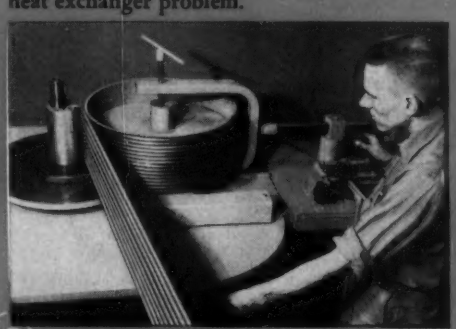

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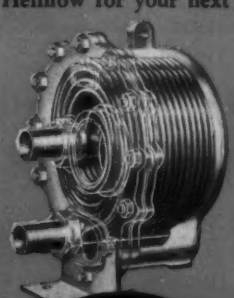

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normal butane and natural gasoline. It will be operated by Warren Petroleum Co. personnel.

Located about two and one-half miles southwest of Bridgeport, the plant is being built as part of the producers' contract with Natural Gas Pipeline Co. of America. Natural, which will transport the gas, is presently building a 350-mile line from the Wise County area to its pipeline terminus at Fritch. Scheduled for completion early in 1958, the line was begun early this year after Natural received a favorable decision from the Federal Power Commission on its application to build the pipeline.

Humble Oil & Refining Co.'s Refining Research and Development division is occupying a newly-completed extension to its main laboratory building at the Baytown, Texas, research center. The 27,000 square foot expansion provides a 70 percent increase in laboratory space and about 40 percent in offices.

Phillips Petroleum Co.'s construction of a 1200-bpd fluid catalytic cracking unit at its Great Falls, Mont., refinery neared completion with erection of a 65-ton prefabricated reactor-regenerator.

Contractor on the project is Procon Inc., Des Plaines, Ill. The refinery addition also was engineered by Procon and is based on Universal Oil Products Co. designs.

By using the prefabricated unit, construction costs were reduced and construction work was speeded up. The unit was fabricated by Lockport Manufacturing Co., Joliet, Ill., and shipped to Great Falls.

Administracion Nacional de Combustibles, Alcohol y Portland (ANCAP) will enlarge its Teja refinery at Montevideo, Uraguay, according to a recent contract between ANCAP, and M. W. Kellogg Co. and Kellogg Pan American. Current rated capacity of the plant is 25,000 barrels daily, which will be more than doubled by the planned additions.

A new atmospheric and vacuum distillation unit, with a capacity of 28,000 bpd; an orthoflow fluid catalytic cracking unit with a daily fresh feed capacity of 5000 barrels daily; a 3000-bpd catalytic reformer; a gas treating unit; and a gas stabilization unit will all be added to the Teja Refinery.

Kellogg is to procure all new equipment going into the new units, and will act in an engineering, design, and advisory construction capacity for ANCAP. The latter will be responsible for actual construction, including the necessary labor.

No probable starting or completion dates for the expansion project have been announced, but work was expected to start in the near future.

L. Sonneborn Sons, Inc., will expand its microcrystalline wax plant at Petrolia, Pa., to include facilities for the manufacture of oxidized microcrystalline type waxes. These hard waxes, which function as replacements for natural or vegetable waxes, are primarily intended for use in the manufacture of emulsion polishes.

A pilot plant for limited production of oxidized waxes has been in operation for some time, according to Sonneborn officials, while construction on its new plant

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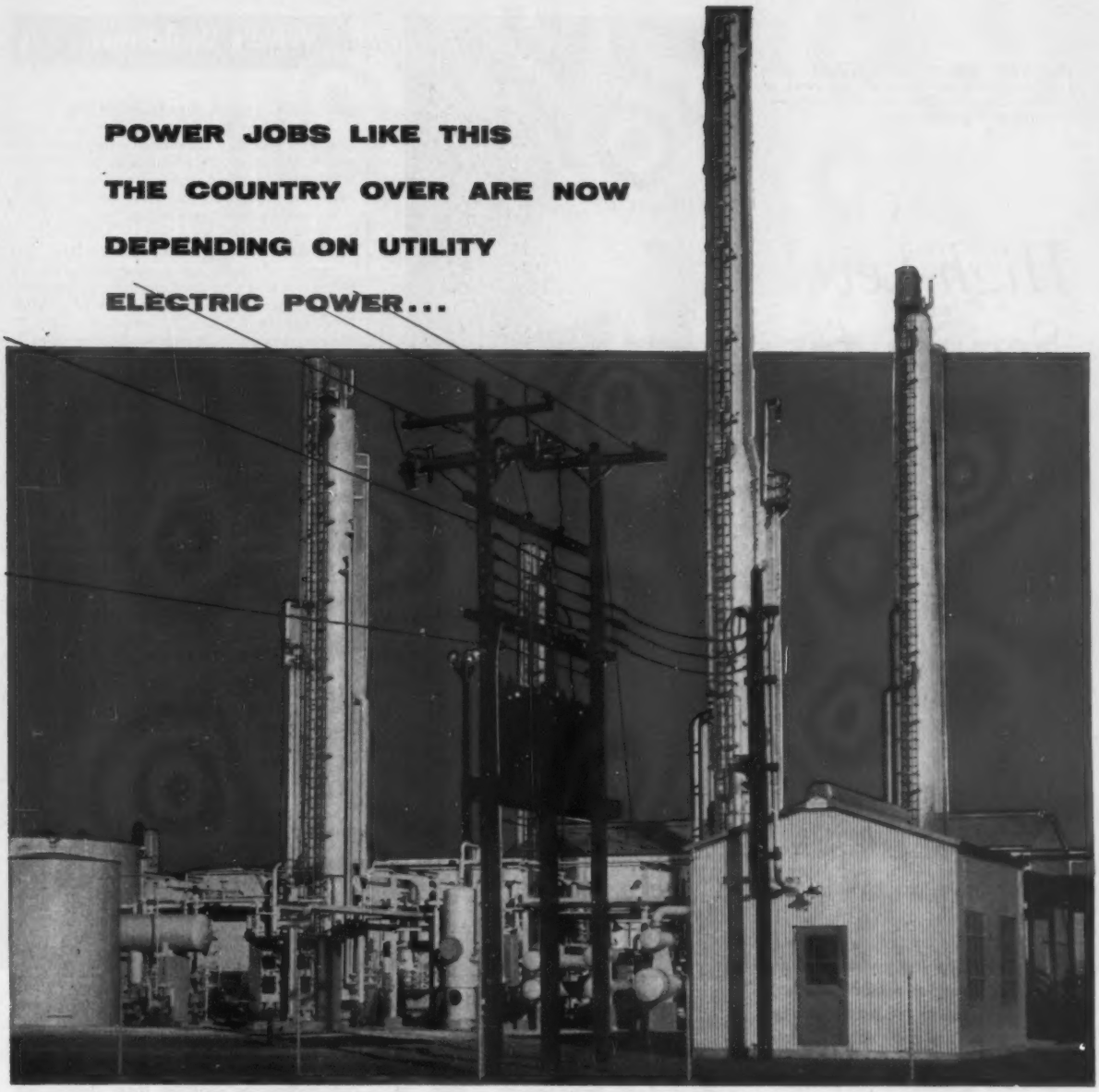

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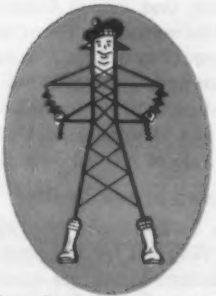

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This SWECO-built stainless-steel catalyst activator operates at red heat in producing polyethylene for Celanese Corporation of America.

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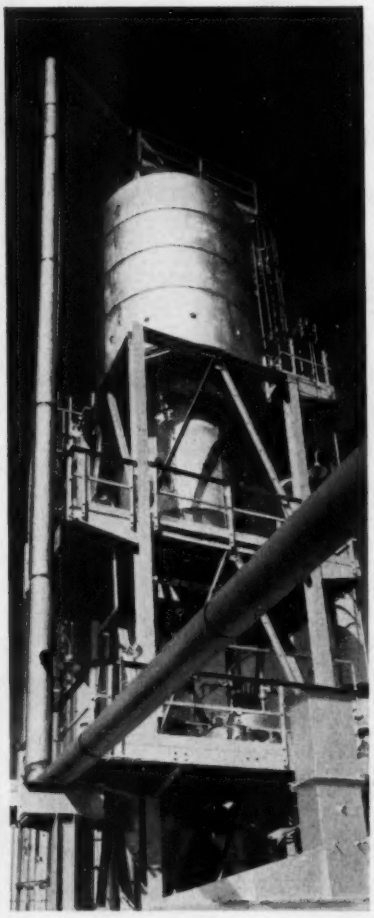

SWECO process equipment helped Celanese Corporation clear the first hurdle in the high-density polyethylene race.

Exacting, high-temperature service for the hottest race in the plastics industry. That's what Celanese Corporation of America had to have to compete with other major chemical companies bidding for leadership in the production of new high-density polyethylene.

SWECO's Manufacturing Division built the stainless-steel catalyst activator and the shell and tube heat exchangers that helped Celanese get into the running. The Celanese Houston (Texas) plant, completed last February by C. F. Braun & Co., Alhambra, Calif., is pouring out spaghetti-like streams of polyethylene at the rate of 100,000 lb. a day.

Operates at red heat

The SWECO-built catalyst activator, designed for red heat operation, is used to activate catalyst for the low-pressure plastic. The new polyethylene retains its strength at the boiling point of water, is stronger and more resistant to heat than polyethylene of low-density, high-pressure manufacture.

Experience: 40 years

The Celanese project is another example of how SWECO – with more than 40 years of experience – serves the process industries...through the design and manufacture of *process equipment* such as heat exchangers, pressure vessels, steam jet ejectors and surface condensers... and through *engineering and construction services* and a complete line of *vibrating screen separators.*

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addition is expected to begin shortly.

Included in the design of the new plant will be separate slabbing equipment for the oxidized waxes which will prevent the mild odor of these waxes from contaminating other microcrystalline waxes which are used in food packaging.

Midland Cooperatives, Inc. has commenced work on a new $600,000 oil blending plant to produce lubricating oils. The plant will be built on the new Midland site in Fridley, Minn., just north of Minneapolis, and is expected to be operating by February 1, 1958. Sumner Sollitt Co., Chicago, is engineer and general contractor for the plant.

The oil blending plant is the second step in the Midland homesite building program. The new Midland warehouse was started last January and was completed in July. Plans for the third step, a modern office building, have not been announced.

The entire plant will be built with an eye to allowing visitors to see how lube oils are blended. Ordinarily the operation of oil blending plants is a closely guarded secret, but thousands of members of Midland cooperatives, who actually own Midland Cooperatives, Inc., will visit the facilities each year. So the plant is designed for their convenience.

Standard Oil Co. of California has acquired land due east of Pearl Harbor in the Ewa area of Hawaii for construction of its $40 million refinery.

The land selected by California-Standard is part of the James Campbell estate. Only recently some 1500 acres of the estate's property in the Ewa district was zoned for industrial use and of this Standard Oil, under the agreement entered into with the estate trustees, will acquire by lease and purchase a total of 310 acres.

The 310 acres selected is in the Barber's Point area and offers unique and extremely favorable conditions for its use as an oil refinery site.

While under the terms of the agreement certain conditions must first be met, when they are accomplished the agreement will be binding on both parties. It is not anticipated that any insurmountable difficulties will be encountered in the fulfillment of these obligations. Standard plans to begin construction as soon as these details are completed.

Reportedly, the refinery will be larger than originally projected and will process approximately 35,000 barrels daily. Standard's plans also call for building a submarine pipe line running out 10,000 feet from shore to a 60 foot depth, to permit handling of the world's largest tankers.

Solvay Process Division, Allied Chemical & Dye Corp., has made the decision to more than double the capacity of its vinyl chloride monomer operation at Moundsville, W. Va.

Solvay Process Division added vinyl chloride to its chemical roster in May 1956 with completion of a plant adjacent to its chlorine-caustic soda and chloromethanes facilities. Decision to enlarge the initial plant is a result of heavy demand for consumer products made from vinyl plastics with consequent increased requirements for Solvay's vinyl chloride monomer.

Solvay Process Division began its Moundsville operations in 1953 with a

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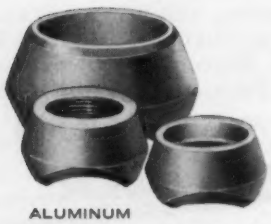

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Who's Building. . .

plant to produce chlorine and caustic soda. In 1954 facilities were added for production of the chloromethanes; methyl chloride, methylene chloride, carbon tetrachloride and chloroform.

Monsanto Chemical Co. has awarded a contract for the engineering, procurement and construction of an insecticide plant to Catalytic Construction Co., Philadelphia.

This new methyl and ethyl parathion facility is to be built at Anniston, Ala., on an accelerated schedule to replace facilities previously operated at Nitro, W. Va. Construction is scheduled to be completed and the plant in operation by December 1, 1957.

Procon Inc. has been awarded a contract covering the engineering and construction of a 3700 bpd UOP Platforming unit at the refinery of Phillips Petroleum Co. at Wood Cross, Utah. Construction is expected to begin in the fall, with completion scheduled for next spring.

The contract includes the erection of a prefractionator and also the construction of certain offsite facilities.

Phillips officials said the Platforming unit will substantially increase the supply of high octane motor fuel needed to meet growing sales demand in the company's Intermountain and Northwest sales territories.

Caltex Oil Refining (India), Ltd., has placed on stream its new 13,500-barrel-per-day refinery. The $29 million plant is on a 515-acre site in the port city of Visakhapatnam, located on India's east coast on the Bay of Bengal. Principal products are gasoline, kerosine, diesel and fuel oils distributed throughout the Visakhapatnam and Calcutta supply areas. Crude oil comes from Sumatra and the Persian Gulf.

Jefferson Lake Sulphur Co. has indicated in a recent report to shareholders it proposes to go ahead with plans to build a sulphur extraction plant just east of Calgary's outskirts.

For several months, the company has been conducting exploratory drilling on an 80,000-acre tract farmout from Mobil Oil of Canada in a move to determine whether sulphur content of the gas in the area would warrant construction of the plant.

Two wells so far drilled have indicated good sulfur content. One with open flow potential of 123 million cubic feet daily tested hydrogen sulphide content of 37 percent and the other tested 35 percent hydrogen sulphide content with open flow potential of 7 million cubic feet daily. Further tests are continuing.

It is understood the company's proposal is to build a plant to produce 425 long tons of sulfur daily and produce between 50 million and 100 million cubic feet of gas daily.

Steelman's Gas Ltd., formerly Provo (Sask.) Ltd., has been granted approval to construct utilities to gather, process and transmit casinghead gas which now is flared in the Steelman field of Saskatchewan.

The Saskatchewan Mineral Resources department sanctioned the $20 million project to be conducted in the Estevan area

For more data on advertised products, use Readers' Service Cards last page.

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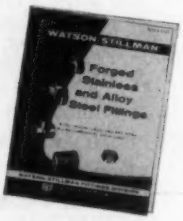
Those are good reasons for "playing it safe" in high pressure service with W-S Forged Stainless or Alloy Steel Pipe Fittings. W-S Stainless Fittings resist corrosion in a wide variety of process liquids and gases and high temperature steam. Available in Types 304, 316 and 304 L.

W-S Alloy Steel Fittings resist oxidation and graphitization and retain their high strength in high pressure—high temperature steam lines. Three alloys available—1¼% Chrome-½% Molybdenum and 2¼% Chrome-1% Molybdenum and 4-6% Chrome-½% Molybdenum.



W-S Forged Stainless and Alloy Steel Fittings can be obtained in Screw-End Type for 2,000 lb., 3,000 lb., and 6,000 lb. WOG service; Socket-Welding Type for Schedules 40, 80, 160 and Double-Extra Heavy Pipe. Send today for bulletin S-1-55.

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W-S FITTINGS DIVISION

Who's Building . . .

120 miles southeast of Regina. An immediate start is to be made and officials estimate it will be completed by September, 1958.

The department estimates that 17 million cubic feet of gas daily now is flared at the field and, with future development, the volume of the casinghead gas is expected to reach 60 million cubic feet daily.

It will be processed into propane, butane, gasoline, sulfur and dry residue gas. The latter will be sold to Saskatchewan Power Corp. for distribution in the province.

Standard Oil Co. (Indiana) has announced a major expansion project for its refinery at Mandan. The company will construct an alkylation unit for making a high octane motor fuel component. The new unit, with a 1630-bpd operating capacity, is expected to be completed by September, 1958. It will employ a process licensed by Phillips Petroleum Co. The construction contract was awarded to the Foster Wheeler Corp. Preliminary work is scheduled to start in September, 1957.

The alkylation unit is the second major addition to Mandan's gasoline-making facilities since the refinery was completed in 1954. The first was an Ultraforming unit, put into operation last year, which also was built for making high octane gasoline.

Canadian Oil Companies, Ltd., may expand its Sarnia, Ontario refinery by adding another 20,000-bpd to its crude capacity. Capacity of the plant was just recently boosted by 50 percent to 30,000 barrels daily. New aromatics recovery facilities were completed two months ahead of schedule, and benzene, toluene, and xylene production is progressing rapidly.

Ashland Oil & Refining Co. has increased the asphalt capacity of its Canton, Ohio, refinery adding a new heater, a vacuum distillation tower, and oxidizing equipment. The vacuum facilities will be on stream by November 15, and the oxidizing unit is due to commence operating in March of next year.

A new udex unit to produce benzene, toulene, xylene, and heavy aromatics for chemical use will be put on stream at the company's Buffalo refinery shortly after the first of the year. Just recently Ashland completed increasing its catalytic reforming capacity at Buffalo and Canton.

Kerr-McGee Oil Industries, Inc., is upgrading octanes and going into the solvents field at its Oklahoma refinery. The company announced, however, that it was temporarily shelving for future consideration, plans for a new udex unit.

The Wilshire Oil Co. of California has placed the latest in petroleum platforming equipment on stream at its Norwalk refinery, it was announced recently by Robert O. Anderson, president.

The unit, a Platformer-Unifiner, can manufacture approximately 400,000 gallons per day of high octane gasoline and will enable Wilshire, California's largest independent refiner and marketer, to make premium grade motor fuels designed for both present day and future high compression engines.

For more data on advertised products, use Readers' Service Cards, last page.

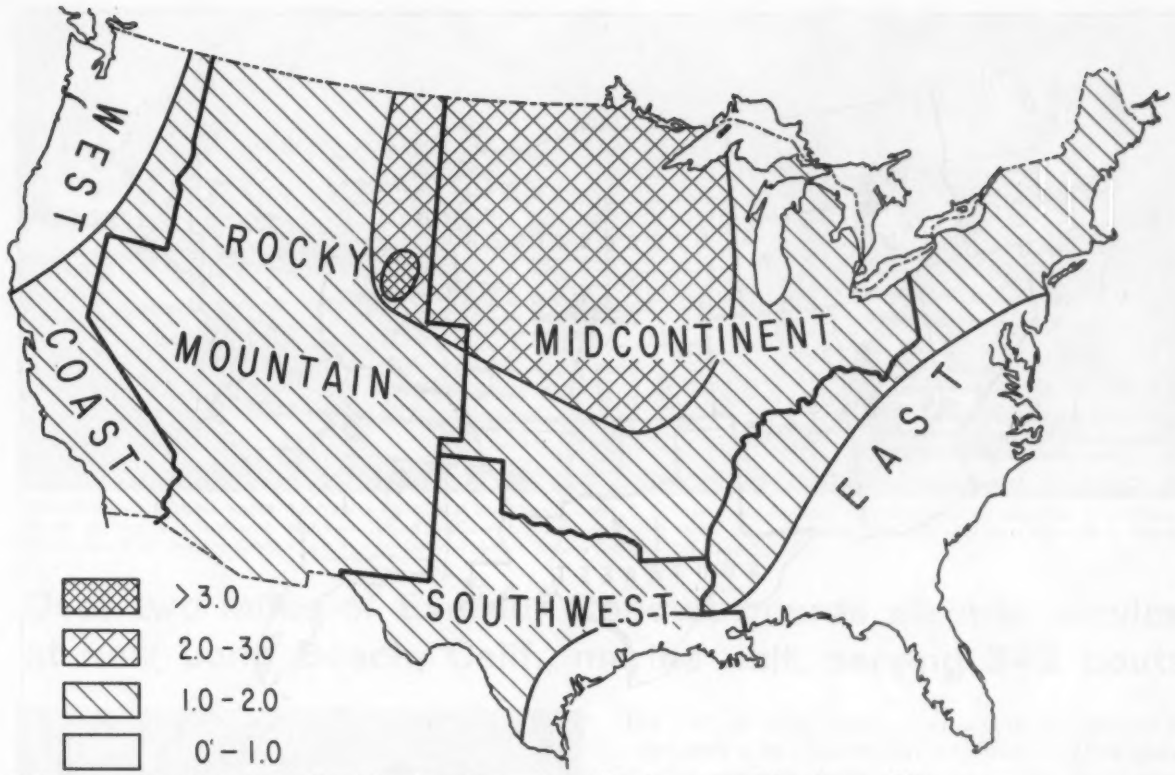


FIGURE 1—Increase in F-1 octane numbers of premium grade gasolines for year preceding August, 1957.

Construction Boxscore data reveal . . .

Octanes Reflect Reforming Increase

Octane increases are varying throughout the U. S. Here's why they are higher in some areas.

BETWEEN THE TIME you put gasoline in your car during September of last year, and when you got the tank filled just last month, the average octane for premium gasoline in your neighborhood probably increased anywhere from 1.0 to 3.0—depending on where you live.

A quick glance at Figure 1 will tell you the octane story for your part of the country. You can see that the Gulf Coast, part of the East Coast, and a small portion of the West Coast all realized the least increase. On the other hand, one small area in the Rocky Mountain section had a phenominal jump of more than three octane numbers.

How can these octanes rise sharply in some parts of the country, yet remain close to constant in other parts?

We were able to ferret out the facts we needed because of the tremendous amount of information which is furnished by companies to PETROLEUM REFINER exclusive feature, "Construction Boxscore." The "Boxscore" is the only feature printed by any magazine which represents a continuing check on refinery, natural gasoline, and petrochemical construction activities all over the world.

By taking the vast amounts of data which are reported to "Construction Boxscore" and which have appeared in it during the past year, we have come up with the correlation that the increase of octane numbers in each part of the country is directly proportional to the percentage of increase of reforming capacity in that part of the country. There is exception to this, and it will be explained later.

Figure 2 gives you the complete story on the percentage of new reforming capacity which has been added during the year preceding July, 1957. This is based on the average crude capacity in these areas. It indicates that the West Coast and the Gulf Coast recorded the least reforming increase, and like we said earlier, these two sections of the U. S. showed the least octane increase.

More specifically, the West Coast has a daily crude capacity of 1.1 million bpd, but the reforming capacity only increased by 14,000 bpd, or 1.2 percent of the total. Similarly, the Southwest section of the U. S. ran 2.9 million bpd, and while the reforming capacity was upped by a

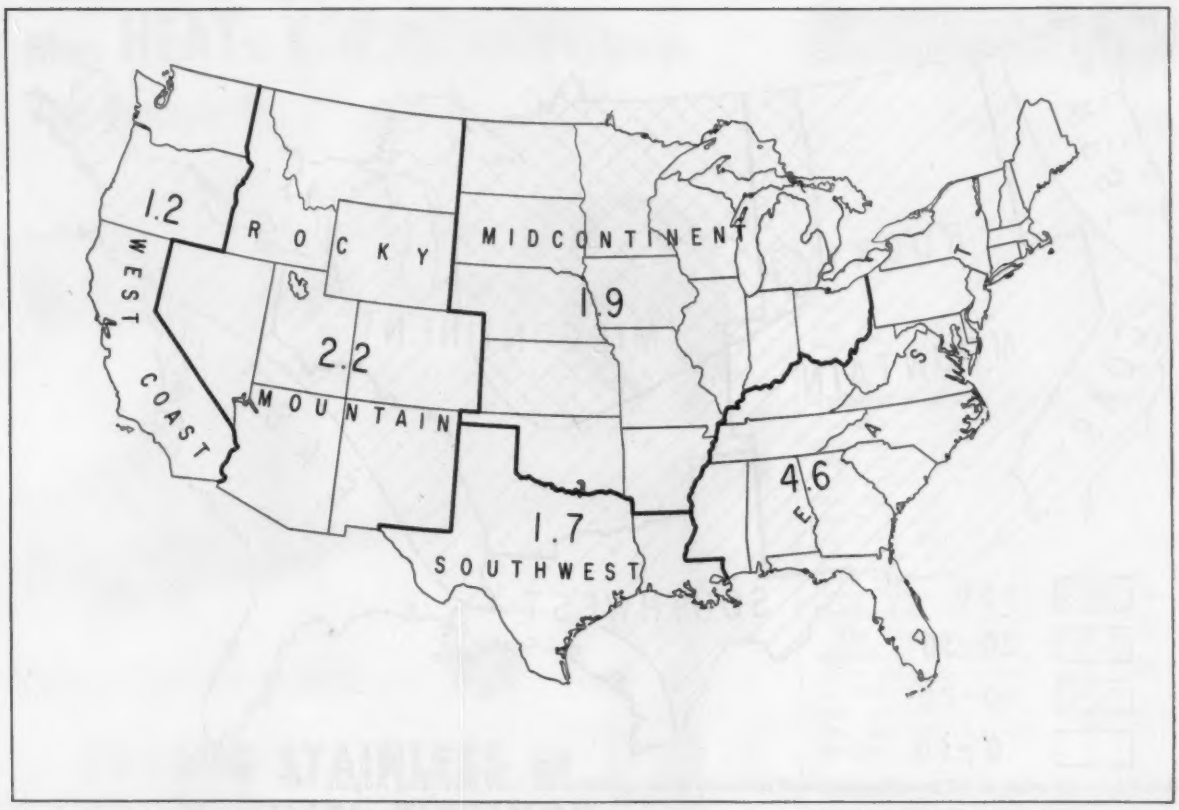


FIGURE 2—Reforming capacity installed for the year preceding July, 1957 reported as a percentage of crude run to stills for each 'Construction Boxscore' area.

whopping 50,500 bpd, that is only 1.7 percent of the total.

The Midcontinent section of the U. S. recorded an octane increase of between 1.0 and 3.0 octane numbers. The daily crude capacity of this section is 2.3 million bpd, and it had the third highest reforming increase with a jump of 43,600 bpd or 1.9 percent.

It is interesting to look at the Rocky Mountain section whose largest area showed an octane increase of between 1.0 and 2.0 numbers. On the other hand, another portion recorded a jump of between 2.0 and 3.0 numbers while still another showed the phenomenal increase of more than 3.0. It is right here that we must keep in mind that most of this territory is so sparsely settled that the small areas of highest increase actually sell more gasoline than all of the rest of the territory.

Running parallel with this increase in octane number is of course the increase in reforming capacity. In the Rocky Mountain area, crude runs to stills averaged only 296,000 bpd, but reforming capacity increased by 6400 bpd for an increase of 2.2 percent.

All of which brings us up to the East Coast which did not follow the pattern, but which is something we expected all along. As you can see, in Figure 2, the East Coast section of the U. S. had only a nominal rise in octane numbers. Most of it was in the 1.0 to 2.0 category while others fell into the 0 to 1.0 class. On the other hand, this section had an average daily crude run of one million bpd with an increase in reforming capacity of 63,100 bpd. Thus, this percentage of reforming increase ran the highest in the nation with a 4.6 percent—yet the octane ratings did not increase accordingly.

The explanation of why these octanes did not react to reforming increase like the rest of the country is forthcoming when we keep several points in mind. The first is that the East Coast already had the highest octanes in the country, and would therefore require a tremendous amount of high octane runs to increase a motor fuel which is already up around 98.

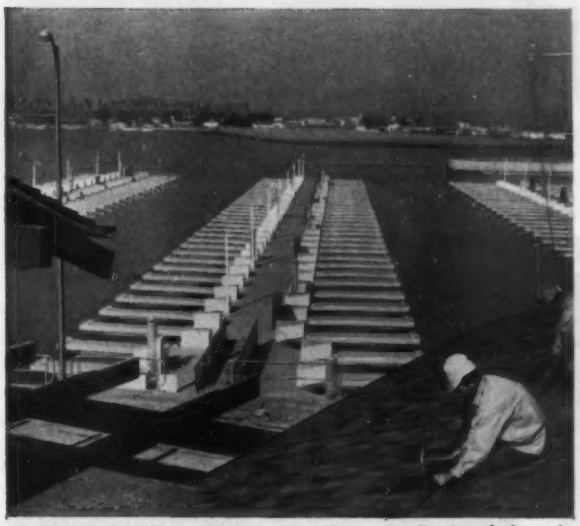
Another point which we should keep in mind, is that in this discussion, we are considering only premium gasoline, not the super-premiums which are now on the market. On the East Coast which pioneered the sales of super-premium, the majority of the new reforming capacity has been thrown into the battle for more and higher octane super-premiums. These two points combine to explain why the East Coast octane numbers have not increased in proportion to the increase in reforming capacity.

Taking a look at the U. S. we find that reforming capacity in this country, by the end of 1955 had risen to 1.04 million bpd. By July, 1956, the reforming capacity had climbed to 1.2 million bpd, and by the end of 1956 it had risen to 1.3 million bpd.

How does reforming capacity stand today? Through the continuing check that "Construction Boxscore" makes quarterly to each company in the U. S. which is doing any type of construction within the refining-natural gasoline-petrochemical industry, PETROLEUM REFINER is able to accurately state that as of this month, October, 1957, reforming capacity

ALAMITOS BAY MARINA BASIN #1, built by the City of Long Beach, Calif: S. E. Vickers, city manager; J. D. Gilkerson, city engineer; B. E. McCune, deputy city engineer; Thomas G. Marchese, project engineer. Engineers: Moffatt & Nichol Inc., Long Beach. Electrical contractor: Ets-Hokin & Galvan, Wilmington, Calif. Everdur Conduit furnished by General Electric Supply Company, Long Beach, Calif.

Over two miles of Everdur Conduit guards electric service at new Long Beach, Calif., marina unit, serving 342 boats



EVERDUR ELECTRICAL CONDUIT is installed under floating docks, only inches above the water. Plug-in electrical outlets are located at lockers by each slip and on lighting standards. *Below:* Everdur Electrical Conduit is available in two wall thicknesses—R. C. and E. M. T.

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The City of Long Beach, Calif., is in the process of transforming its Alamitos Bay area from tide flats and a massive mosquito factory into one of the finest small boat harbors in the world.

The first boat basin and marina unit, which can accommodate 342 boats, is now complete. The floating docks are well lighted and at each slip, boat owners have plug-in electric service and a fresh water tap. All electrical wiring from the shore out is protected by Everdur® Electrical Conduit – well over 11,000 feet, ranging from ½" nominal size to 3". In addition, all fittings and boxes are of Everdur.

Everdur Electrical Conduit – made from one of Anaconda's copper-silicon alloys–never rusts and offers high resistance to other types of corrosion. It provides dependable year-after-year protection wherever water and corrosive atmospheres are a problem – or where conduit must be buried or embedded in concrete. Everdur is also tough – it stands up under movement and vibration.

For detailed information, write: The American Brass Company, Buffalo Division, Buffalo 5, N. Y. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

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Performance exceeds claims for G-29 steam-hydrocarbon reforming catalyst

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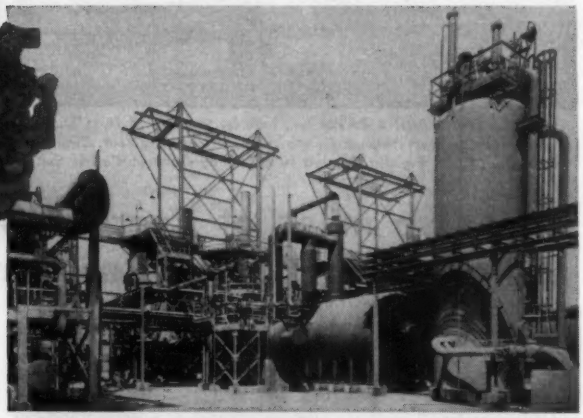
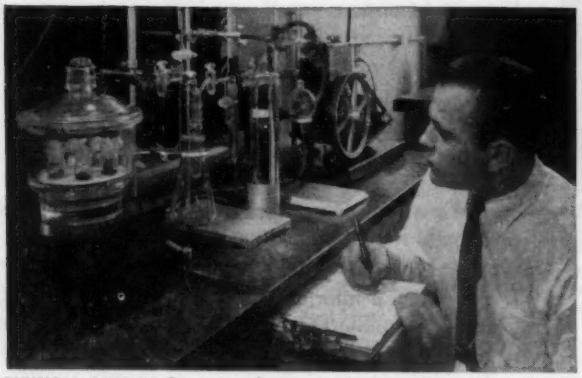


USED IN ADAMS TERMINAL AMMONIA PLANT of Phillips Chemical Company. Girdler catalyst specialists studied the production of ammonia synthesis gas in secondary reformers. Cooperating with Girdler, the Phillips Chemical Company ran pilot plant tests and selected G-29 catalysts for this application. Results: Catalyst performance exceeds Girdler claims. *Methane in reformer effluent is less than 0.1 mol percent at normal operation.*



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EVEN MORE REFORMING CAPACITY WILL BE GOING IN

Construction Boxscores Areas	Crude Run To Stills Thousands of BPD	Reforming Capacity Installed Thousands of BPD			
	Average*	Jul. '56-Jul. '57		Jul.-Oct. '57	After Oct. '57
East	1,390	63.1	(4.6)**	42.2	52.0
Mid-Continent	2,270	43.6	(1.9)	47.0	80.8
Southwest	2,900	50.5	(1.7)	44.0	168.0
Rocky Mountains	300	6.4	(2.2)	3.5	22.8
West Coast	1,140	14.0	(1.2)	3.5	59.5
Total	8,000	188.0	(2.3)	140.2	382.3

* U. S. Dept. of Interior, Bureau of Mines, June 1956 through May 1957.

** Numbers in parentheses are percentages of crude run to stills.

within the continental U. S. stands at 1.5 million bpd.

The table above reveals that another 382,300 bpd have been announced for construction, to be completed at some future date. This total is broken down to give you an idea as to where the new units will be built.

With the increase in reforming throughout the country, octane ratings can do nothing but continue to climb. Of course the higher they get, the slower the rate of increase will be, but nevertheless, we predict that by this time next year, "Construction Boxscore" will have recorded another country-wide increase in octanes.

Construction BOXSCORE

REFINERIES, NATURAL GASOLINE AND PETROCHEMICAL PLANTS

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
Allied Chemical & Dye	Linden, N.J.	Sulfuric Acid	60 tons	.....	Under Constr.	Late 1957	.....	Girdler	Girdler
	Moundsville, W. Va.	*Inc. Vinyl Chloride Monomer Cap.	.....	.....	Planning	.....	.....	.....	.....
American Cyanamid..	Santa Rosa City, Florida	Acrylic Fiber	27,000,000 bbls/yr.	.....	Planning	1958	.....	.....	.....
American Oil Co.....	Yorktown, Va.	Gas Treating Sulphur Recovery	50 tons	.....	Engineering	Nov., 1957	.....	Fluor	Fluor
Ashland Refining.....	Buffalo, N.Y.	Aromatics	45,000 gals.	.....	.....	.....	.....	.....	.....
Atlantic Refining.....	Philadelphia	Unifiner-Catformer;	15,000 bbls. †75 tons	Part of $11,500,000 Program	Complete	.....	Atlantic	Blaw Knox	Blaw Knox
Cary Chemicals.....	Flemington, N.J.	PVC Resin Plt.	12,000,000 lb./yr.	$1,500,000	Complete	.....	.....	Scientific Design	Scientific Design
California Oil Co.....	Perth Amboy, N.J.	Splitting Tower & Offsite Facilities	.....	.....	.....	.....	.....	Foster Wheeler	.....
Chemstrand.....	Decatur, Ala.	Exp. Acrilan Plt.	45,000,000 lbs./yr.	.....	Under Constr.	1st Qtr., 1958	.....	Staff	Daniel Constr.
	Pensacola	Exp. Nylon Plt.	114,000,000 lbs./yr.	.....	Under Constr.	2nd Qtr., 1958	.....	Staff	.....
Cities Service.....	Linden, N.J.	Refinery Modernization	.....	.....	Planning	1958	.....	.....	.....
		Asphalt Plt.	.....	.....	.....	1958	.....	.....	.....
Columbia Gas.....	Siloam, Ky.	*Hydrocarbon Fractionation Plt.	.....	.....	.....	.....	.....	Pritchard	Pritchard
Commerce Oil Ref....	Jamestown, R.I.	Refinery,	40,000 bbls.	$50,000,000	Planning	1957	UOP	Fluor	Fluor
		Cat. Cracking	25,000 bbls.						
		Crude Units	40,000 bbls.						
Du Pont.....	Belle Works, W. Va.	Urea: Ammonia Methyl Methacrylate, Nylon Intermediates	.....	.....	Planned	1959	.....	.....	.....
Escambia Chemical...	Pensacola, Fla.	Methanol	18,000,000 gal./yr.	.....	Under Constr.	March, 1958	.....	Chemico; Badger Mfg.	.....
Esso Standard.....	Everett, Mass.	Powerformer	7,200 bbls.	.....	Complete	.....	Esso	Esso	Badger Mfg.
	Linden, N.J.	Ethylene Plt.	.....	.....	Under Constr.	.....	.....	S&W	S&W
		Alkylation	10,700 bbls.	$8,000,000	Under Constr.	4th Qtr., 1957	Esso	Parsons	Parsons
	Bayway	Hydrofiner	15,000 bbls.	.....	.....	.....	.....	Foster Wheeler	Foster Wheeler
		Powerformer	20,000 bbls.	.....	Complete	.....	Esso	Foster Wheeler	Foster Wheeler

* First appearance in tabulation † Added capacity

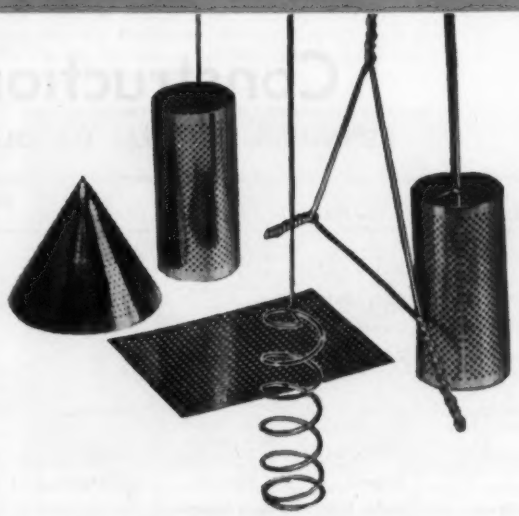
Construction BOXSCORE Continued on Page 203

RUPTURE DISCS... discs of precious metals, resistant to most corrosive agents and unattacked under conditions that base metals could not withstand. Specific physical properties ensure bursting only at the predetermined pressure.

DEOXO® PURIFIER... provides low-cost catalytic purification of hydrogen and other gases to the extent of less than one part oxygen per million. Requires no operating expense, no maintenance, no reactivation, no auxiliary heating, no water cooler. Extremely simple installation.

important for petroleum processing...

SUPER-SENSITIVE DEOXO® INDICATOR... for measuring oxygen or hydrogen present as impurities in other gases. Accurately indicates from 0.0002% to 0.0200% (2 to 200 parts per million) oxygen, and from 0.0004% to 0.0400% hydrogen. A dual range permits measurement of up to 0.25% oxygen or 0.5% hydrogen.



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ENGELHARD INDUSTRIES

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Food Machinery & Chemical Corp.	S. Charleston, W. V.	Exp. Carbon Tetrachloride Plt.	.....	.....	Engineering	Mid 1958	.....	Staff, Fluor	Fluor
Frontier Refining.....	Buffalo, New York	Aromatics Plts.	45,000 gal.	$2,500,000 and $1,250,000 off-site facilities	Engineering	Early 1958	UOP	UOP	Procon
General Aniline & Film	Linden, N.J.	Ethylene Oxide: Ethylene Glycol	.....	$8,000,000	Under Constr.	1957	Scientific Design	Scientific Design	Scientific Design
Goodrich Chemical Co.	Calvert City, Ky.	Acrylic Polymers	.....	$2,500,000	Under Constr.	Late, 1957	.....	.....	Wigton-Abbott
Goodrich-Gulf.....	Institute, W. Va.	Boiler House	.....	.....	Complete	.....	.....	Girdler	Girdler
Gulf Oil.....	Philadelphia	Cat. Reformer I	26,000 bbls.	.....	Under Constr.	Late 1957	UOP	Procon	Procon
		Cat. Reformer II	26,000 bbls.	.....	Under Constr.	Early 1958	UOP	Procon	Procon
	Near Charleston, S.C.	Refinery	.....	.....	Considering	.....	.....	.....	.....
Hercules Powder.....	Parlin, N.J.	Polyethylene	30,000,000 lbs./yr.	$10,000,000	Under Constr.	.....	.....	.....	.....
Kendall Refining.....	Bradford, Pa.	Unifiner	2,000 bbls.	$300,000	Complete	.....	UOP	UOP	Staff
Koppers.....	Woodbridge, N.J.	Polyethylene	30,000,000 lbs./yr.	.....	Under Constr.	1957	Koppers	Koppers	Koppers
	Kobuta, Pa.	Polystyrene	.....	.....	Under Constr.	Early, 1958	.....	Staff	Staff
Leonard Refineries....	Alma, Mich.	*FCC	7,500 bbls.	.....	.....	.....	.....	.....	.....
Paragon Oil Co.....	Tiverton, R.I.	Refinery	30,000 bbls.	$35,000,000	Planning	.....	.....	.....	.....
Pennsalt.....	Calvert City, Ky.	Organic-Fluorine	.....	.....	Under Constr.	.....	.....	Staff	Miller & Johnson
Rhode Island Ref....	Tiverton, R.I.	.....	.....	.....	Planning	.....	.....	.....	.....
Sinclair Refining.....	Marcus Hook, Pa.	Gasoline Fractionation	10,000 bbls.	.....	Engineering	Early, 1958	.....	Fluor	Fluor
Socony Mobil.....	Paulsboro, N.J.	Hydrodesulfurization	22,000 bbls.	.....	Complete	.....	.....	Foster Wheeler	Foster Wheeler
	Buffalo, N.Y.	Alkylation	2,440 bbls.	.....	Engineering	.....	.....	Kellogg	Kellogg
Spencer Chemical....	Henderson, Ky.	Urea Plt.	100 tons	.....	Planning	Summer 1958	Montica-tinni	Staff	Quaker Valley
The Southland Co....	Black Point, Fla.	Refinery	15,000 bbls.	$12,000,000	Planning	.....	.....	.....	.....
Standard-Indiana.....	Mandan, N.D.	*Alkylation Unit	1,630 bbls.	.....	Under Constr.	Sept., 1958	Phillips	Foster Wheeler	Foster Wheeler
Sunshine States Refineries	East Tampa, Fla.	*Refinery	20,000 bbls.	$27,000,000	Under Design	1959	.....	Kaiser	Kaiser
Sun Oil Company....	Marcus Hook, Pa.	Additions to Research Ctr.	.....	$1,400,000	Complete	.....	.....	Staff	Nason and Cullen
Thompson Chem.....	North Dighton, Mass.	Polyvinyl Chloride Plt.	.....	.....	Complete	.....	Scientific Design	Scientific Design	.....
Tidewater Oil.....	Delaware City	*Hydrogen Plt.	30 mm scf	.....	Complete	.....	.....	.....	.....
Union Carbide Chemicals	Institute, W.V.	Exp. Acrylonitrile Plt.	.....	.....	.....	2nd Qtr., 1958	.....	.....	.....
	Winfield, W. Va.	*Petrochemical Plt.	.....	.....	Planning	1960	.....	.....	.....
United Fuel Gas Co...	Kenova, W.V.	Hydrocarbon Extraction Plt.	.....	$8,000,000	Engineering	Dec., 1958	.....	Pritchard	Pritchard
U. S. Rubber.....	Naugatuck, Conn.	Exp. Synthetic Rubber Plt.	† 40%	.....	.....	1957	.....	.....	.....
		Exp. Organic Chemicals Plt.	† 15%	.....	.....	1957	.....	.....	.....
MID-CONTINENT									
Advance Refining.....	Centralia, Ill.	Inc. Crude Cap.	3,000 bbls.	.....	Complete	.....	.....	Litwin	Staff
Amoco Chemical Corp.	Joliet, Ill.	Phthalic Anhydride Isophthalic Acid, Terephthalic Acid, Diemthyl Terephthalate, Dimethyl Isophthalate Benzoic Acid	60,000,000 lbs./yr.	$10,000,000	Under Constr.	1958	.....	Scientific Design	Scientific Design Plants
Anderson-Prichard....	Cyril, Okla.	Cat. Crkr, Fractionation; Light-Ends Recovery; Revamping	5,000 bbls.	.....	Complete	.....	UOP	Procon	Procon
	Arkansas City, Kans.	Propane Deasphalting Unit	3,000 bbls.	.....	Complete	.....	Esso	Badger Mfg.	Badger Mfg.
		Vacuum Tower	15,000 bbls.	$1,200,000	Engineering	.....	.....	Blaw-Knox	Blaw-Knox
Aurora Gasoline Co,..	Detroit, Mich.	Fluid Coker	4,000 bbls.	.....	Complete	.....	Esso	Parsons	Parsons
	Muskegon, Mich.	Vac. Cap.	6,000 bbls.	.....	Complete	.....	.....	.....	.....
Ben Franklin Refining	Ardmore, Okla.	HF Alkylation	1,000 bbls.	$800,000	Under Constr.	Late, 1957	UOP	Treco	Treco
Callery Chemical.....	Muskogee, Okla.	*Hydrogen Plt.	800,000 scf	.....	.....	.....	.....	.....	.....
		*Nitrogen Plt.	200,000 scf	.....	Engineering	3rd Qtr., 1958	.....	Girdler	Girdler
		*Carbon Dioxide	7,790 lbs./hr.	.....	.....	.....	.....	.....	.....
Century Refining.....	Garden City, Kans.	Cat Reformer	800 bbls.	$150,000	Posponed	1957	UOP	Litwin	Staff
Champlin Oil & Ref...	Enid, Okla.	HF Alky Unit	1,430 bbls.	$1,900,000	Engineering	March, 1958	Phillips	Badger Mfg.	Badger Mfg.
Clark Oil & Ref.....	Chicago	Refinery Expansion	9,000 bbls.	$5,000,000	.....	.....	.....	.....	.....
		Vacuum Unit	.....	.....	.....	.....	.....	UOP	CB&I; Morrison
		Alkylation	.....	.....	.....	March, 1958	UOP	Dushell	Morrison
		Gas Recovery	.....	.....	.....	March, 1958	UOP	UOP; Procon	Procon
		Cat Cracker	.....	.....	.....	March, 1958	UOP	UOP; Procon	Procon
Coastal Chemical Corp.	Pascagoula, Miss.	*Phosphoric Acid & Ammonium	350 tons	$1,900,000	Under Constr.	Dec., 1957	St. Gobain	Fluor	Fluor
		*Phosphate Sulfuric Acid Plt.	600 tons	$1,350,000	Under Constr.	Dec., 1957	Titlestad	Titlestad	M. T. Reed
		*Offsite Facilities	.....	$2,500,000	Under Constr.	Dec., 1957	.....	Staff	.....
Commercial Solvents..	Terre Haute, Ind.	Plant Expansion	.....	$2,000,000	Complete	.....	.....	Staff	Local
Cooperative Refinery Asso.	Phillipsburg, Kans.	Unifiner	3,500 bbls.	$1,500,000	Under Constr.	Early, 1958	UOP	Sweco	Sweco
		Platformer	2,500 bbls.						
	Coffeyville, Kans.	*Hydrofluoric Alkylation Unit	1,100 bbls.	$1,500,000	.....	June, 1958	.....	Treco	Treco
Dow Chemical.....	Bay City, Mich.	Ethylene Plt.	.....	.....	Under Constr.	Jan., 1958	.....	.....	.....
		Gas Purification	.....	.....	Engineering	.....	.....	Girdler	Austin
du Pont.....	Ecorse, Mich.	*Sulfuric Acid Plt.	.....	.....	Under Constr.	Early 1958	.....	Staff	Staff
D-X Sunray.....	Duncan, Okla.	Unifining	6,000 bbls.		Under Constr.	Late 1957	UOP	Treco	Treco
	Tulsa	Unifining	20,000 bbls.						
		HF Alkylation	2,500 bbls.	$10,000,000	Under Constr.	Early 1958	UOP	Treco	Treco
		Butane-isomerization	2,500 bbls.						
		Platformer, Rerun Tower & LPG Recovery Unit	12,000 bbls.						
Ethyl Corp.....	Joliet, Ill.	Antiknock Compounds	.....	.....	Planned	.....	.....	.....	.....
Hawthorne Chemical Co.	Louisiana, Mo.	Methacrylate Plt.	35,000,000 lbs./yr.	$11,000,000	Engineering	.....	.....	.....	.....
Hercules Powder.....	Louisiana, Mo.	Formaldehyde Plt.	100,000,000 lbs./yr.	.....	Complete	.....	.....	.....	.....
		Pentaerythritol Plt.	24,000,000 lbs./yr.	.....	Complete	.....	.....	.....	.....

• First appearance in tabulation † Added capacity

Construction BOXSCORE Continued on Page 205

AMERICAN
AIR LIQUIDE
ENGINEERING & CONSTRUCTION DIVISION

OLDEST IN EXPERIENCE — NEWEST IN DESIGN

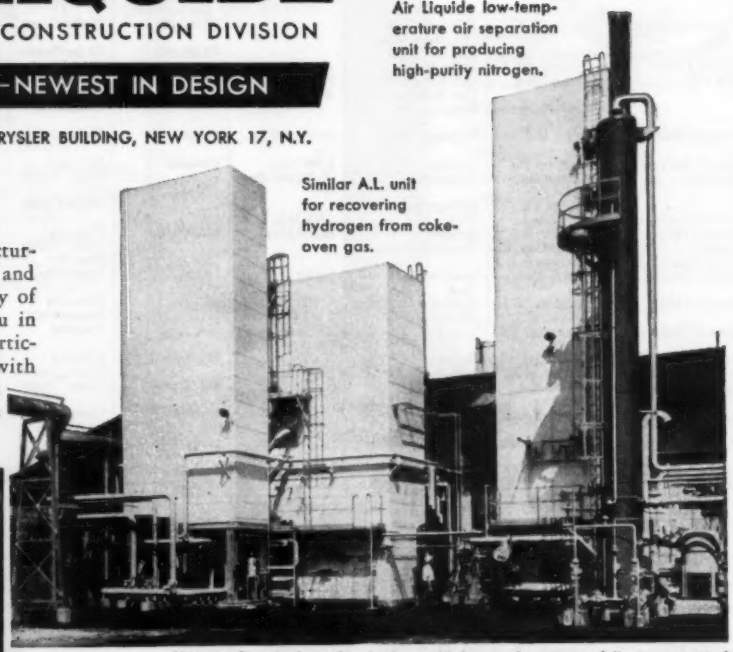
529 CHRYSLER BUILDING, NEW YORK 17, N.Y.

In Canada: **L'Air Liquide**
1111 Beaver Hall Hill
Montreal, Que.

Our widely-experienced technical and manufacturing staff, including design, process, project and mechanical engineers, backed by half a century of "know-how," is at your service to assist you in applying low-temperature technology to your particular requirements. We shall be glad to consult with you regarding cost analyses and technical aspects in the design and manufacture of complete plants or components "tailored" to your needs.

Air Liquide low-temperature air separation unit for producing high-purity nitrogen.

Similar A.L. unit for recovering hydrogen from coke-oven gas.



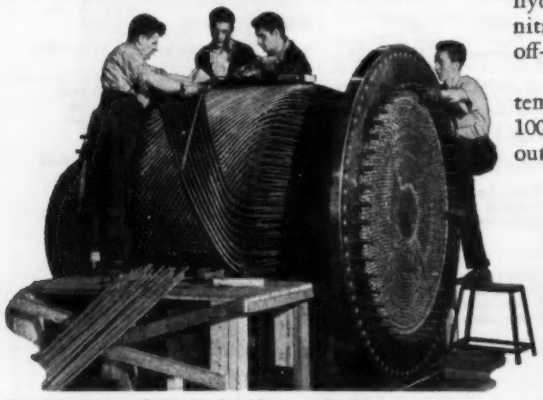
Ketona Chemical, at Birmingham, Alabama, has successfully inaugurated the first ammonia plant in this country designed exclusively around coke-oven gas as a source of hydrogen. The low-temperature gas separation units used at Ketona were designed and built by American Air Liquide.

A portion of Air Liquide's Engineering and Construction Division fabricating plant at Montreal, Que. Under fabrication here are numerous all-welded stainless steel shells to house component exchangers, vaporizers, rectification columns, etc., of the liquefaction equipment.

Low-temperature separation processes, for recovering atmospheric and hydrocarbon gases in tonnage quantities, are being used on a rapidly increasing scale in the United States.

Once confined to the separation of oxygen, nitrogen and the rare gases of the atmosphere, the low-temperature liquefaction process of separation is today successfully producing high-purity hydrogen, pure carbon monoxide, methane, ethylene, propane and nitrogen, from such gaseous mixtures as: natural gas, refinery off-gases and coke-oven gas.

During the past 50 years, Air Liquide (a pioneer in the low-temperature gas separation field) has designed and built more than 1000 hydrocarbon and air-separation plants for industries throughout the world. In the United States it is a leader in this field.



The fabrication of an Air Liquide wound tube-type exchanger can involve over 10 miles of intimately interwoven copper tubing to provide the necessary cooling surfaces in this specialized low-temperature equipment.

Centre of control panel for a large-tonnage oxygen plant includes a flow sheet for the operator's guidance. Once put "on stream", operation of Air Liquide low-temperature plants is almost entirely automatic.

L'Air Liquide, its affiliates and subsidiaries have offices and plants throughout the world: Algeria, Argentina, Belgium, Brazil, Cameroon, Canada, China, Egypt and Sudan, France, French Congo, French West Africa, Gold Coast, Great Britain, Greece, Indochina, Italy, Ivory Coast, Japan, Lebanon, Luxemburg, Madagascar, Malay States, Morocco, Netherlands, Paraguay, Portugal, Siam, South Africa, South-East Asia, Spain, Sweden, Syria, Tunisia, and the United States of America.

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
		Methanol Plt.	7,000,000 gal./yr.	$2,000,000	Complete	.....	Vulcan	Vulcan	Vulcan
Kerr McGee	Wynnewood, Okla.	Platformer	5,500 bbls.	$4,500,000	Under Constr.	Spring 1958	UOP	UOP, Nofsinger	Treco
		Dist. Unifiner	4,000 bbls.						
Leonard Refineries	Alma, Mich.	Hydrofiner	5,200 bbls.	.....	Complete	.....	Std. (N.J.)	Pritchard	Pritchard
		*FCC Unit	7,500 bbls.	.....	.....	Aug., 1958	.....	.....	.....
Mississippi Chemical Corp.	Yazoo City, Miss.	*Add Nitric Acid Plt.	150 tons	$1,500,000	Under Constr.	Feb., 1958	.....	C & I	C & I
Monsanto Chemical	Monsanto, Ill.	Phenol Plt. Exp.	25 percent	.....	.....	.....	.....	.....	.....
Naph-Sol Refining Co.	Muskegon, Mich.	Cat. Reformer	6,000 bbls.	.....	Complete	.....	.....	.....	.....
Northwestern Ref. Co.	St. Paul Park, Minn.	Cat. Reformer	6,000 bbls.	$2,500,000	Planning	Jan., 1959	.....	.....	.....
Olin Mathieson	Mapleton, Ill.	Antifreeze Plt.	.....	$1,500,000	Under Constr.	Spring, 1958	.....	.....	P. S. Edwards Company
Pana Refining Co.	Pana, Ill.	Modernization	†1,600 bbls.	$900,000	.....	.....	.....	.....	.....
Petroleum Specialties	Flat Rock, Mich.	Visbreaker	3,000 bbls.	$250,000	Planning	.....	.....	Litwin	.....
Preston Oil Co.	Siloam, Ky.	*Hydrocarbon Fractionation & Storage Plt.	.....	$1,714,000	Under Constr.	Dec., 1958	.....	Pritchard	Pritchard
Prime Oil Co.	Calumet City, Ill.	Refinery	15,000 bbls.	$10,000,000	Planned	.....	.....	.....	.....
The Pure Oil Co.	Lemont, Ill.	Cat. Reformer	12,000 bbls.	.....	Under Constr.	Fall, 1957	.....	Kellogg	Kellogg
		Feed Prep Unit	17,000 bbls.	.....	.....	.....	.....	.....	.....
Reichhold Chemicals	Tuscaloosa	Formaldehyde Plt.	35,000,000 lbs./yr.	.....	Planning	1957	Staff	Staff	Staff
	Detroit	Formaldehyde Plt.	35,000,000 lbs./yr.	.....	Planning	1957	Staff	Staff	Staff
Rock Island Refining	Indianapolis	Inc. Unifining Cap.	4,600 bbls.	.....	Complete	.....	UOP	UOP	Staff
		Inc. Platforming	2,800 bbls.	.....	Engineering	.....	UOP	UOP	Staff
Shell Oil	Wood River, Ill.	Effluent Treat. Facilities	.....	$1,000,000	Under Constr.	Late 1957	.....	.....	.....
Sinclair Oil & Gas	Garfield City, Okla.	*Deisobutanizer	20,000 gals.	.....	Under Constr.	Jan., 1958	.....	.....	.....
Sinclair Refining	East Chicago	Hydrofinishing	.....	$1,300,000	Complete	.....	.....	Treco	Treco
		MEK Deoiling	1,000 bbls.	.....	Engineering	Fall 1958	Texaco	Badger Mfg.	Badger Mfg
		Gaso. Fractionation	18,000 bbls.	.....	Under Constr.	Early, 1958	.....	Fluor	Fluor
	Wood River, Ill.	Cat. Reformer	7,500 bbls.	$7,000,000	Complete	.....	.....	McKee	McKee
Skelly Oil Co.	El Dorado, Kan.	HF Alkylation	3,000 to 4,000 bbls.	.....	Engineering	Early, 1958	Phillips	Staff	Staff
	Medicine Lodge, Kans.	Exp. Natural Gaso. Plt.	40,000 gals.	.....	Under Constr.	Jan., 1958	.....	Staff	....
Socony Mobil	East St. Louis	Sovaformer	12,000 bbls.	.....	Planning	1957	.....	Fluor	Fluor
		Pretreater	16,000 bbls.	.....	Planning	1957	.....	Fluor	Fluor
	Augusta, Kans.	Cat. Reformer	9,000 bbls.	$2,800,000	Complete	.....	.....	Pritchard	Pritchard
	Trenton, Mich.	Alkylation Unit	3,500 bbls.	$3,500,000	Engineering	Early, 1958	.....	Fluor	Fluor
Standard-Indiana	Sugar Creek, Mo.	Alkylation	3,800 bbls.	.....	Complete	.....	.....	Foster Wheeler	Foster Wheeler
	Whiting, Ind.	Ultraformer I	21,000 bbls.	.....	Complete	.....	Std (Ind.)	Parsons	Parsons
		Ultraformer II	21,000 bbls.	.....	Under Constr.	1957	Std. (Ind.)	McKee	McKee
	Neodesha, Kans.	Ultraformer	6,000 bbls.	.....	Under Constr.	Early 1958	Std. (Ind.)	Foster Wheeler	Foster Wheeler
	Wood River, Ill.	Crude Unit	67,500 bbls.	.....	Under Constr.	Early 1959	.....	.....	McKee
	Mandan, N. D.	*Alkylation Unit	1,630 bbls.	.....	Under Constr.	Sept., 1958	.....	.....	.....
Standard (Ohio)	Toledo, Ohio	Refinery Exp.	†60,000 bbls.	$40,000,000	Under Constr.	Mid. 1958	.....	Kellogg	Kellogg
	Elmore, Okla.	Exp. Gasoline Plt.	†2k Mmcf	.....	Under Constr.	.....	.....	.....	.....
	Cleveland, Ohio	Alkylation	3,000 bbl.	$3,000,000	Planning	May, 1958	.....	.....	McKee Co.
Sun Oil	Toledo	*Alkylation Plt. Exp.	.....	$1,000,000	Under Constr.	Dec., 1958	.....	Staff	Catalytic
The Texas Co.	Lockport, Ill.	Convert Hydroformer to Platformer	10,000 bbls.	.....	Under Constr.	4th Qtr., 1957	.....	UOP	Staff
		Ammonia Plt.	180 tons	.....	Under Constr.	4th Qtr., 1957	.....	Foster Wheeler, C&I	Foster Wheeler, C&I
U. S. I. C.	Tuscola, Ill.	Polyethylene Plt. Exp.	300,000 lbs.	.....	Complete	.....	I.C.I.	.....	.....
Vickers Petroleum	Potwin, Kans.	Ultraformer	3,500 bbls.	$1,000,000	Complete	.....	Std.-Ind.	Parsons	Parsons
		Udex Unit	15,000,000 gals./yr.	$2,000,000	Under Constr.	1st Qtr., 1958	UOP	Procon	Procon
Warren Petroleum Sunray	Forgan, Okla.	*Gasoline Plt.	.....	$2,000,000	Engineering	Aug., 1958	.....	.....	.....
Westland Oil Co.	Williston, N.D.	Inc. Platformer	530 bbls.	$260,000	Under Constr.	Dec., 1957	UOP	UOP	Staff
		Therm Cracker	1,000 bbls.	$500,000	Complete	.....	.....	UOP	Pet. Pipe Cont.
Wisconsin Oil Refining Co.	Sheboygan, Wis.	Vacuum Unit	2,500 bbls.	.....	Complete	.....	.....	Koch	.....
SOUTHWEST									
Aluminum Co. of America	Port Lavaca, Texas	Gas Processing Plt.	100 MMSCFD	$1,500,000	Under Constr.	1957	.....	Pregle, Dukler & Crump	Staff
American Cyanamid	Frontier, La.	Acrylonitrile Plt.	.....	$25,000,000	Under Constr.	1958	.....	.....	.....
American Oil	Texas City	Ultraformer & Desulfurization Unit	21,000 bbls.	.....	Engineering	Early 1958	.....	Parsons	Parsons
American Petrofina	Wichita Falls, Texas	Platformer	3000	$625,000	Complete	.....	UOP	Tears	Tears
Anchor Gasoline Corp.	E. Krotz Springs, La.	*Gasoline Plt.	25 MMcf	$500,000	Under Constr.	Nov., 1957	March Co.	Charlie Barry Co.	Jay Pierce
Atlantic Refining	Pt. Arthur, Texas	Unifiner-Catformer	15,000 bbls.	Part of $11,500,000 Program	Complete	.....	Atlantic	Blaw-Knox	Blaw-Knox
		Alkylation Unit	2,100 bbls.	.....	Under Constr.	Spring, 1958	.....	Fluor	Fluor
	Crane, Texas	Gasoline Plt.	20.5 Mmcf	.....	Under Constr.	1957	.....	Delta	Delta
Atlas Processing	Shreveport, La.	*Isomerization Unit	3,500 bbls.	.....	Under Constr.	Early, 1958	UOP	.....	.....
Calcasieu Chemical	Lake Charles	Ethylene Oxide; Ethylene Glycol	8,000,000 gals./yr.	.....	.....	Early, 1958	Shell	.....	Lummus
Calumet Refining	Princeton, La.	Crude Oil Distil.	2,000 bbls.	.....	Under Constr.	Nov., 1957	.....	Kellogg, Staff	Staff
Carbide & Carbon	Seadrift, Texas	Ethylene Oxide Exp.	To 200,000,000 lbs./yr.	.....	Planning	.....	.....	.....	.....
		Inc. Ethylene Glycol Cap.	To 65,000,000 lbs./yr.	.....	Planning	.....	.....	.....	.....
Celanese	Bishop, Texas	Plt. Expan.	25 Percent	.....	Under Constr.	1957	.....	.....	.....
	Pampa, Texas	Acrylate Ester Plt.	15,000,000 lbs./yr.	.....	Under Constr.	Late 1957	.....	.....	.....
Chemoil Corp.	New Orleans	Refinery	40,000 bbls.	$35,000,000	Design	.....	.....	Lummus	Lummus
Cities Service	Lake Charles, La.	Inc. Reforming Cap.	.....	.....	Planning	.....	.....	.....	.....
		Ethylene Plt.	2,000,000 lbs./yr.	.....	.....	.....	.....	.....	.....
	Dora Roberts Ranch, Texas	Natural Gaso. Plt.	.....	.....	Under Constr.	.....	.....	.....	.....
Commercial Solvents	Sterlington, La.	Methanol, Ammonia Nitrate	.....	$8,000,000	Complete	.....	.....	Ford, Bacon, Davis: Staff	Ford, Bacon, Davis

* First appearance in tabulation † Added capacity

Construction BOXSCORE Continued on Page 206

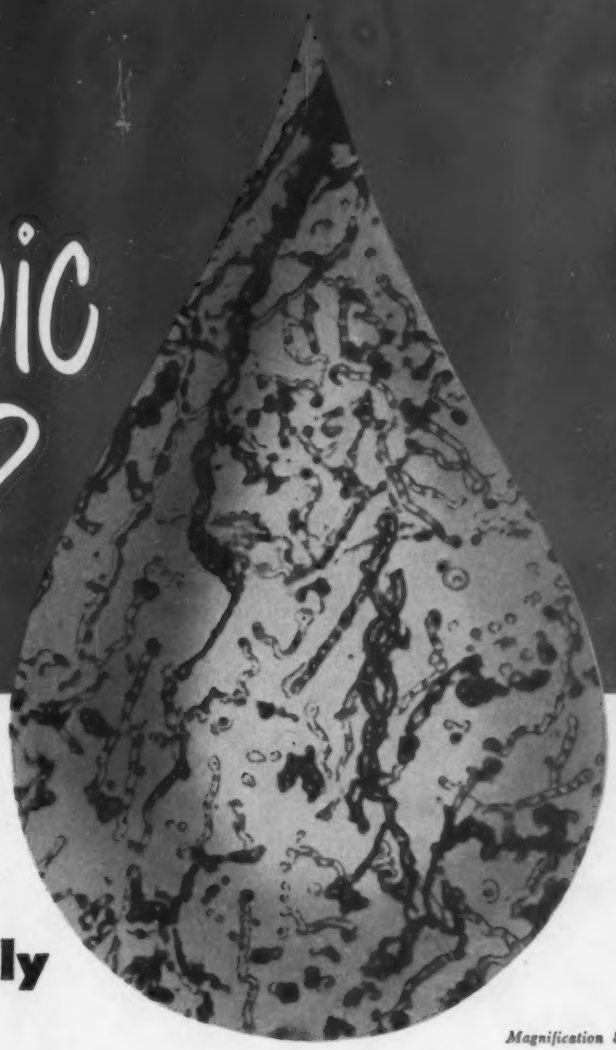
CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Consolidated Chemical, Ind.	Baytown	*Sulfur Recovery Plt.	.....	.....	Under Constr.	1st Qtr., 1958	.....	Parsons	Parsons
Continental Oil	Wichita Falls, Texas	Cat. Reformer	3,500 bbls.	$1,450,000	Under Constr.	Spring, 1958	.....	Treco	Treco
	Lake Charles La.	Coking-Calcining Unit	10,000 bbls.	$6,250,000	Under Constr.	1957	.....	Fluor	Fluor
	Gretna, La.	*Exp. Petrochemical Plt.	.....	.....	Under Constr.	.....	.....	.....	.....
Copolymer Rubber & Chemical	Baton Rouge	Plt Exp. Butadiene	35,000 short tons yr.	.....	.....	Late 1957	.....	.....	.....
Cosden Pet.	Big Spring, Texas	Styrene Plt.	†3,000 bbls.	$1,200,000	Complete	.....	.....	.....	.....
Diamond Alkali	Houston	Perchlorethylene Exp.	50 percent	.....	Under Constr.	.....	.....	.....	.....
		Acetylene Plt.	.....	.....	Engineering	.....	.....	.....	.....
	Deer Park	Vinyl Chloride Plt.	.....	$10,000,000	Engineering	Early, 1958	.....	Scientific Design	Brown & Root
Dorchester, Corp.	White Deer, Texas	Cat. Reformer	1,000 bbls.	$400,000	Under Constr.	1957	Atlantic	Grebe & Doremus	Staff
Dow Chemical	Plaquemine, La.	Ethylene and Propylene Glycols and Oxides, Chlorinated Solvents	.....	Part of $50,000,000	Under Constr.	1958	.....	.....	.....
	Freeport, Texas	Acetylene, Methyl-acetylene, Ethanolamines, Synthetic Glycerine, Butadiene, Chlorine, Ethylene Oxide, Methyl Chloride, Glycerine, Glycol, Perchloro Ethylene and Styrene	.....	$45,000,000	Under Constr.	1958	.....	.....	.....
		*Glycerine Plt.	.....	.....	Under Constr.	.....	.....	.....	.....
Du Pont	Orange	Polyethylene	.....	.....	Under Constr.	1958	.....	.....	.....
	Near New Orleans	Petrochemical Plt.	.....	.....	Considering	.....	.....	.....	.....
	Beaumont, Texas	Chlorinated Polyethylene Plt.	.....	.....	Complete	.....	.....	du Pont	du Pont
	Victoria, Texas	Crude Hydrogen	.....	.....	Under Constr.	Feb., 1958	.....	Girdler	Staff
Eastern States Petroleum Co.	Houston	*Exp. Platformer	4,000 bbls.	.....	Complete	.....	UOP	Staff	Staff
		*Exp. Chemical Fract.	7,000 bbls.	.....	Complete	.....	.....	Staff	Staff
El Paso Natural Gas Products	Odessa, Texas	Refinery	6,500 bbls.	.....	Under Constr.	Early, 1958	UOP	Fish	Fish
		Alkylation Blending	.....	.....	Planning	.....	.....	.....	.....
Esso Standard	Baton Rouge	Ethylene, Butadiene Expan.; Wax, Lube Oil, Avgas	.....	$40,000,000	.....	.....	.....	.....	.....
		Powerformer	25,000 bbls.	.....	Under Constr.	2nd Qtr., 1958	.....	Esso	Bechtel
		Alkylation	6,500 bbls.	.....	Designing	3rd Qtr., 1959	.....	Esso	.....
		LPG Storage	1,000,000 bbls.	.....	Under Constr.	1957	.....	.....	.....
Ethyl Corp.	Baton Rouge	Vinyl-Chloride Monomer Pet.	.....	.....	Under Constr.	Late 1957	.....	Cat. Constr.	Cat. Constr.
Evangeline Refining	Jennings, La.	Catformer	1,000 bbls.	.....	Considering	.....	.....	.....	.....
General Tire	Odessa, Texas	Copolymer Plt.	40,000 tons/yr.	$10,000,000	Complete	.....	.....	General Tire	Ferguson
Grace Chemical	Baton Rouge, La.	Polyethylene	50,000,000 lbs./yr.	$18,000,000	Under Constr.	1957	Phillips	Fluor	Fluor
Gulf Oil	Pt. Arthur, Texas	Polymerization Inc.	2,800 bbls.	.....	Complete	.....	.....	Gulf; Procon	Procon
		Greasemaking; Packaging	.....	.....	Under Constr.	Late 1957	.....	Summer Sollitt	Summer Sollitt
		Sludge Decomposer	125 tons	.....	Complete	.....	Monsanto; Sonneborn	Leonard	Leonard
		Platformer	26,000 bbls.	.....	Under Constr.	Early 1958	UOP	Procon	Procon
		*Gasoline Processing	10,000 bbls.	.....	Engineering	Late, 1958	UOP	Procon	Procon
J.M. Huber	Borger, Texas	Furnace Black	20-30,000,000 lbs./yr.	.....	Planning	.....	.....	.....	.....
Humble	Baytown, Texas	FCC	51,200 bbls.	.....	Under Constr.	Feb., 1958	.....	Foster Wheeler	Foster Wheeler
		Benzene Plt.	30,000,000 gal./yr.	.....	Under Constr.	Dec., 1957	.....	Badger Mfg.	Badger Mfg.
		Ethylene Recovery Plt.	80,000,000 lbs./yr.	.....	Under Constr.	July, 1958	.....	Kellogg	Kellogg
		Hydrodesulfurization Unit I	43,200 bbls.	.....	Under Constr.	Nov., 1957	.....	Parsons	Parsons
		Hydrodesulfurization Unit II	43,200 bbls.	.....	Under Constr.	Dec., 1957	.....	Parsons	Parsons
		Butyl Exp.	13,000 tons/yr.	.....	Under Constr.	March, 1958	.....	Staff	Staff
		*Varsol Hydrofining	6,000 bbls.	.....	Engineering	May, 1958	.....	Hudson	Hudson
		*Phenol Lube Plt. No. 2	31,500 bbls.	.....	Engineering	Aug., 1958	.....	Kellogg	Brown & Root
	Kleberg County, Texas	Gas Process & Cycling Plt.	750 mmcf	$75,000,000	Planning	Mid 1959	.....	.....	.....
Jefferson Chemical	Port Neches, Texas	Inc. Ethylene Cap. Inc. Ethylene Glycol Cap. Inc. of Ethylene Oxide Cap.	.....	.....	Engineering	Mid 1958	Scientific Design	Scientific Design	.....
La Gloria Oil & Gas	Falfurrias, Texas	Exp. Gaso. Plt.	2,200 bbls.	.....	.....	.....	.....	.....	Hudson
Magnolia	Beaumont, Texas	Crude Distil.	100,000 bbls.	.....	Under Constr.	Mid 1958	.....	Foster Wheeler	Foster Wheeler
		Alkylation Unit	8,000 bbls.	.....	Under Constr.	Early 1958	.....	Staff, Braun	Braun
		Sulfur Recovery Unit	70 light tons	.....	Under Constr.	Early 1958	.....	Foster Wheeler	Foster Wheeler
		*Sovaformer	30,000 bbls.	.....	Under Constr.	Late, 1958	.....	Staff, Foster Wheeler	Staff, Foster Wheeler
		*Exp. LPG Fractionation	.....	.....	Engineering	Mid 1958	.....	Magnolia, Fluor	Fluor
McBride Refining Co.	Port Brownsville, Texas	Ref. Expan.	†2,500 bbls.	$2,500,000	Planned	.....	.....	.....	.....
Merichem	Houston	Plant Expan.	.....	$1,000,000	Complete	.....	.....	Tears	Brown & Root
Monsanto	Texas City	Exp. Acrylonitrile Plt.	100,000,000 lbs./yr.	.....	Under Constr.	Early 1958	.....	.....	.....
		*Inc. Styrene Monomer Cap.	†40,000,000 lbs./yr.	.....	.....	June, 1958	.....	.....	.....
National Petro-Chemical	Houston	*Polyethylene Plt.	75,000,000 lbs./yr.	.....	.....	Late, 1958	.....	Kellogg	Kellogg
Neches Butane Products	Port Neches, Texas	Butadiene Plt. Exp.	300,000 tons/yr	.....	Under Constr.	Mid, 1958	.....	Foster Wheeler	Foster Wheeler
North American Petroleum	Corpus Christi	Refinery	.....	.....	Planning	.....	.....	.....	.....
Northeast Texas Chemical Co.	East Texas	Chemical and Fertilizer Plt.	.....	.....	Planning	.....	.....	Tears	Beck
Odessa Styrene	Odessa, Texas	Styrene Plt.	35,000,000 lbs./yr.	$5,000,000	Engineering	Jan., 1958	UOP	Fish	Fish

* First appearance in tabulation † Added capacity

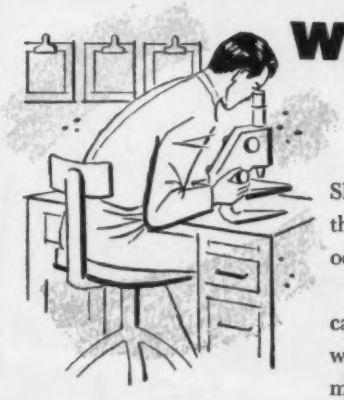
Construction BOXSCORE Continued on Page 209

Microscopic Enemies?



Magnification 800X

Layne Research Defends Your Well Water Supply



Shown here is an actual photograph of one of the many microscopic organisms which may occur in any type water supply.

Layne Research is called upon when well capacity is reduced. Layne Research finds out why. Production records, water analysis and microscopic examinations are some of the methods used to find the reason. Layne Research, thru years of experience in "recovering lost water," selects the correct Laynite material and method to restore well capacity.

IDENTIFY AND PRESCRIBE — that's what Layne Research does for each individual well water problem.

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News on Ethylene from England

Imperial Chemical Industries Ltd., the largest chemical manufacturing firm in the British Commonwealth, is meeting the increased demands for ethylene-derived products with a third ethylene manufacturing plant in northeast England. As the discoverer and a major producer of polyethylene, I.C.I. consumes large amounts of high purity ethylene.

The M. W. Kellogg organization was privileged to engineer I.C.I.'s first two ethylene plants. Kellogg is completing the engineering of the third plant, and has started construction. All three plants utilize the unique Kellogg steam-cracking process which produces exceptionally high yields of over 99% pure ethylene with a high on-stream efficiency.

The close cooperation and interchange of technology between I.C.I. and Kellogg will assure the success of this new plant as it did for the two now in operation. Kellogg's ability to work closely and harmoniously with chemical companies is largely responsible for the organization's leading international position in petrochemical engineering.

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CHEMICAL PROCESS DIVISION

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CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Ohio Oil Company	Orange, Texas	Gasoline Plt.	10 Mmcf	$800,000	Under Constr.	1957	.....	Olsen	Olsen
Petroleum Chemicals	Lake Charles	Anhydrous Ammonia	100,000 tons/yr.	$12,500,000	Under Constr.	Late 1957	.....	Foster Wheeler	Foster Wheeler
		Ethylene Plt.	19,000,000 lbs./yr.	.....	Under Constr.	Jan., 1958	.....	Lummus	Lummus
		Butyl Rubber Plt.	30,000 tons/yr.	$17,000,000	Engineering	Early 1959	.....	Foster Wheeler	Foster Wheeler
Petro-Tex Chemical	Houston	Butadiene Expansion	110,000 tons/yr.	$30,000,000	Complete	.....	.....	Bechtel	Bechtel
Phillips Chemical	Gulf Coast	Carbon Black	64,000,000 lbs./yr.	.....	Planning	.....	.....	.....	.....
	Pasadena, Texas	Polyethylene	205,000 lbs.	.....	Complete	.....	.....	Phillips	Farnsworth & Chambers
	Phillips, Texas	Exp. Butadiene Cap.	104 tons	.....	Complete	.....	.....	Telleysen; Phillips	Phillips
Phillips Petroleum	Sweeny, Texas	Nat. Gas Liquid Fractionation	15,000 bbls.	.....	Under Constr.	1957	.....	Phillips	S&W
		Inc. Alkylation	2,000 bbls.	.....	Under Constr.	1957	.....	Phillips	Phillips
		Inc. Cat. Reformer	2,000 bbls.	.....	Complete	.....	.....	Phillips	Phillips
		Inc. Nat. Gas Liq.	20,000 bbls.	.....	Under Constr.	Fall, 1957	.....	Phillips	S&W
		Cat. Reformer; Desulfurization	16,000 bbls.	.....	Engineering	1958	.....	Phillips	Fluor
Rohm & Haas	Houston	Acetylene	.....	.....	Under Constr.	Fall 1957	.....	Chemico	Chemico
		Methanol	.....	.....	Under Constr.	Fall 1957	.....	Foster Wheeler	Foster Wheeler
		Ammonia	.....	.....	Under Constr.	Fall 1957	.....	Foster Wheeler	Foster Wheeler
Shamrock Oil & Gas	Dumas, Texas	Inc. Crude Cap.;	20,000 bbls.	.....	.....	Fall 1957	.....	Staff	Staff
		Inc. Sulfuric Acid Alkylation	3,600 bbls.	.....	.....	Fall 1957	.....	Staff	Staff
		N-Butane Isomerization	2,000 bbls.	.....	.....	Fall 1957	Phillips	Staff	Leonard Constr.
		Isobutane Cracking	1,500 bbls.	.....	.....	Fall 1957	Phillips	Staff	Leonard Constr.
		Sludge Regen. and Contact	75 tons	.....	.....	Early 1958	Monsanto	Leonard Constr.	Leonard Constr.
		Sulfuric Acid Plt.	75 tons	$850,000	Under Constr.	.....	.....	.....	.....
Shell Chemical	Norco, La.	Methyl Ethyl Ketone	.....	.....	Under Constr.	Fall 1957	.....	Braun	Braun
Shell Oil	Norco	Cat. Gasoline Fractionator	.....	.....	.....	.....	.....	Foster Wheeler	Foster Wheeler
		Platformer	.....	.....	Planning	.....	.....	.....	.....
Sinclair Refining	Corpus Christi	Cat. Reformer	6,500 bbls.	.....	Under Constr.	Spring 1958	.....	Fluor	Fluor
		Gaso. Fractionation	5,400 bbls.	.....	Und Constr.	Spring 1958	.....	.....	Fluor
	Houston	Hydrodesulphurization	24,000 bbls.	$5,600,000	Under Constr.	Fall, 1957	.....	Parsons	Parsons
		Gaso. Fractionation	27,000 bbls.	.....	Under Constr.	Early 1958	.....	.....	Fluor
	Hulldale Field, Texas	Desulfurizer	.....	.....	Under Constr.	.....	.....	.....	.....
Spencer Chemical	Orange, Texas	Polyethylene Exp.	90,000,000 lbs./yr.	.....	Under Constr.	Summer, 1958	.....	Staff	Quaker
Standard-Texas	El Paso	FCC	27,000 bbls.	.....	Under Constr.	Dec., 1957	Esso	Fluor	Fluor
		Ref. Exp.	†25,000 bbls.		Under Constr.	4th Qtr. 1957	Esso	Staff, Fluor	Fluor
Suntide Refining	Corpus Christi	Unifiner	6000 bbls.	.....	Complete	.....	UOP	UOP, Treco	Treco
		Rexformer	15,000 bbls.	$5,000,000	Complete	.....	UOP	UOP, Treco	Treco
		Udex Unit	4500 bbls.		Complete	.....	UOP	UOP, Treco	Treco
Texas City Refining	Texas City	Houdriformer	7,000 bbls.	$2,000,000	Complete	.....	Houdry	Catalytic	Catalytic
The Texas Co.	Port Arthur	Power Plant	.....	.....	Under Constr.	4th Qtr., 1957	.....	Jackson & Moreland	Texaco
		Crude Unit	86,000 bbls.	.....	Under Constr.	3rd Qtr., 1958	.....	Fluor	Fluor
		Cat Cracker	60,000 bbls.	.....	Under Constr.	3rd Qtr., 1958	.....	Kellogg	Kellogg
		Inc. Alkylation	2000 bbls.	.....	Under Constr.	3rd Qtr., 1958	.....	Staff	Staff
		Cat. Reformer	20,000 bbls.	.....	Engineering	4th Qtr., 1958	.....	UOP	.....
		Udex Unit	28,000 bbls.	.....	Engineering	4th Qtr., 1958	.....	UOP & Others	Staff & Others
Tidewater Oil	New Hope, Texas	Injection Plt.	15 MMcf	$700,000	Under Constr.	1957	.....	Olsen	Olsen
Union Oil & Gas et al	Eunice, La.	Gasoline Plt.	300 Mmcf	.....	Complete	.....	.....	Fluor	Fluor
U. S. Rubber	Baton Rouge, La.	Petrochemicals	.....	$5,000,000	Under Constr.	Nov., 1957	.....	Kidde Engrs.	.....
Warren Petroleum	Barbers Hill	Light Hydrocarbon Fractionation Plt.	44,000 bbls.	$6,000,000	Complete	.....	.....	Pritchard	Pritchard
Wiseco Gas Processing	Wise County, Texas	Gasoline Plt.	150 MMcf	$3,700,000	Under Constr.	Early 1958	.....	Olsen	Olsen
Wickett Refining	Wickett, Texas	Catformer	1,000 bbls.	.....	Projects being held up	.....	.....	.....	.....
		Unifiner	1,000 bbls.	.....		.....	.....	.....	.....
Wyandotte Chemicals	Geismar, La.	Ethylene-Oxide Glycol	60,000,000 lbs./yr.	$8,000,000	Approved	Late 1957	Shell	Lummus	Lummus
ROCKY MOUNTAIN									
Apache Powder Co	Curtiss, Ariz	Ammonia Synthesis Plt.	.....	$1,000,000	Engineering	Late 1957	.....	Girdler	Staff
Bay Petroleum	Denver	Cat. Reformer	3,800 bbls.	$1,200,000	Under Constr.	Early 1958	.....	Kellogg	Kellogg
Cabot Carbon	Lovington, N.M.	*Gasoline Plt.	6 MMcf	$1,000,000	Under Constr.	Nov., 1957	.....	Gas Plt. Constr.	.....
Continental Oil Co.	Denver	Cat. Reformer	3,500 bbls.	$1,400,000	Complete	.....	.....	Staff, Treco	Treco
El Paso Natural Gas Products Co.	Gallup, N.M.	Refinery; Alkylation, Cat Reforming, Cat. Cracking, Vacuum, Crude Unit	9,000 bbls.	$10,000,000	Under Constr.	Fall 1957	UOP	Sweco	Sweco
	Bloomfield, N.M.	*National Gasoline	165 MMcf	$3,800,000	Under Constr.	Jan., 1958	.....	Stearns-Roger	Stearns-Roger
Empire Petroleum	Denver	Hydrosulfurization	1,000 bbls.	.....	Project Suspended		British Petroleum	Litwin	.....
Farmers Union Central Exchange	Laurel, Mont.	*Naphtha Unifiner	4,400 bbls.	.....	Under Constr.	Early 1958	UOP	.....	Treco
		*Platformer	5,100 bbls.	.....	.....	.....	.....	.....	.....
		Distillate Unifiner	7,100 bbls.	.....	.....	.....	.....	.....	.....
First National Petroleum Corp.	Jensen, Utah	Ref. Expan.	To 3,000 bbls.	.....	Complete	.....	.....	Staff, Procon	Procon
Frontier Refining	Cheyenne, Wyo.	Revamp Vac. Unit	.....	.....	Under Constr.	Late 1957	.....	Treco-Staff	Treco-Staff
Phillips Petroleum	Woods Cross, Utah	Cat Reformer	3,700 bbls.	.....	Under Constr.	Spring, 1958	.....	.....	Procon
Salt Lake Refg.	Salt Lake City	Inc. Cap.	3,000 bbls.	.....	Complete	.....	.....	.....	.....
		Reformer	6,000 bbls.	.....	Under Constr.	Nov., 1957	.....	.....	Fluor
Sioux Oil	Newcastle, Wyo.	Gas Processing Plt.	4 MMcf	.....	Complete	.....	.....	Litwin	Staff
		Add Crude Cap.	6,000 bbls.	.....	Complete	.....	.....	Litwin	Staff
Socony Mobil	Casper, Wyo.	Cat. Reforming	3,250 bbls.	.....	Under Constr.	Nov., 1957	.....	Pritchard	Pritchard
		Cat. Hydrodesulfurization	3,400 bbls.	.....	Under Constr.	Nov., 1957	.....	Pritchard	Pritchard
Standard-Indiana	Casper, Wyo.	Lube Oil Plt.	5,000 bbls.						
		Vacuum Pipe Still	4,800 bbls.						
		Propane Deasphtg.	1,000 bbls.	.....	Under Constr.	1957	.....	Foster Wheeler	Foster Wheeler
		Furfural Extraction	1,500 bbls.				Texaco		
		MEK Dewaxing, Deoiling	2,000 bbls.				Texaco		

* First appearance in tabulation † Added capacity

Construction BOXSCORE Continued on Page 210

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Tennessee Gas	Lea County, N. M.	Gas Process Plt.	10 MMcf	.....	Engineering	Early 1958	.....	.....	.....
The Texas Co.	San Juan County, Utah	*Gasoline Plt.	.....	.....	.....	.....	.....	.....	.....
Utah Oil Refining	Salt Lake City	CO Boiler for FCU	.....	$970,000	Under Constr.	March, 1958	.....	Stearns-Roger	Stearns-Roger
		*Crude Unit	35,000 bbls.	$2,000,000	Engineering	Mid 1958	.....	Fluor	Fluor
Western States	North Salt Lake City	Houdriformer	1,000 bbls.	.....	Under Constr	.....	.....	.....	.....
WEST COAST									
Bankline Oil	Bakersfield, Calif.	Desulfuriser	3,800 bbls.	$100,000	Complete	.....	Sinclair; Baker	Staff, Kellogg	.....
Cal-Mex Oil & Refining	San Diego	Refinery	20,000 bbls.	.....	Engineering	Early 1959	.....	Parsons	Parsons
Douglas Oil Co.	Los Angeles	Unifiner	.....	.....	Under Constr.	1957	.....	.....	Macco
		Topping Plt.	12,000 bbls.	.....	Planned	.....	.....	.....	.....
Du Pont	Antioch, Calif.	Fluorinated Hydrocarbons, Tetraethyl Lead	.....	.....	Under Constr.	.....	.....	.....	.....
Ethyl Corp.	San Francisco	Anti-knock Compound Mfg. Plt.	.....	.....	.....	Mid 1958	.....	Braun	Braun
Fletcher Oil	Wilmington, California	Unifiner Platformer	.....	.....	Under Constr.	Spring, 1958	UOP	Parsons	Parsons
General Petroleum	Ferndale, Wash.	Cat. Reformer	9,000 bbls.	.....	Under Constr.	Late 1957	.....	Socony, Bechte	Bechtel
	Torrance, Calif.	Cat Reformer	12,000 bbls.	.....	Under Constr.	Late 1957	.....	Staff-Parsons	Parsons
Golden Bear Oil Co.	Oildale, Calif.	Revamp Furfural Treating Unit	.....	$100,000	Under Constr.	Late 1957	Texaco	Staff-D.G. Reynolds	.....
Reichhold Chemicals	South San Francisco	Plasticizers	.....	.....	Under Constr.	Late 1957	.....	Staff	Staff
Richfield Oil	Everett, Wash.	Refinery	50,000 bbls	.....	Planning	.....	.....	.....	.....
	Los Angeles	*Benzene Plt.	18,000,000 gal./yr.	.....	Under Constr.	May, 1958	.....	.....	.....
Shell Chemical	Torrance, Calif.	Mod. Copolymer Plt.	.....	.....	Complete	.....	.....	.....	.....
	Domingues, Calif.	Exp. Isopropyl Alcohol Facl.	.....	.....	Under Constr.	Fall 1958	.....	.....	.....
Shell Oil	Martinez	Platformer	16,000 bbls.	.....	.....	Early 1958	.....	Kaiser	Kaiser
	Anacortes, Wash.	Alkylation Unit	.....	.....	Engineering	Mid 1958	.....	Fluor	Fluor
	Wilmington	Boiler for Cat. Cracker	200,000 lbs.	$1,000,000	Under Constr.	.....	.....	.....	.....
Standard Oil (Calif.)	Everett, Wash.	Refinery	60,000 bbls.	$75,000,000	Planning	1961	.....	Staff-Bechtel	Bechtel
	Bakersfield	Cat Reformer	5,000 bbls.	$4,500,000	Engineering	Mid 1958	.....	Staff-Bechtel	Rosendahl Corp.
	Richmond	Cat Reformer	20,000 bbls.	$11,000,000	Engineering	Mid 1958	.....	Staff-Bechtel	Bechtel
		Paraxylene Plt.	.....	$3,000,000	Engineering	Early 1958	.....	.....	.....
		Revamp 2 Crude Units	.....	.....	Complete	.....	.....	Staff-Bechtel	Bechtel
	El Segundo	*Deisobutaniser	†300 bbls.	$250,000	Under Constr.	Dec., 1958	.....	Macco	Macco
Straits Refining	Puget Sound	Refinery	8,000 bbls.	$26,430,000	ODM Approved	.....	.....	Tears	Tears
Sunland Refining Co.	Bakersfield	*Platformer	1,000 bbls.	.....	Complete	.....	UOP	.....	.....
The Texas Co.	Anacortes, Wash.	Refinery	40,000 bbls.	.....	Under Constr.	Jan., 1959	.....	Bechtel	Bechtel
	Los Angeles	Udex Unit	9,000 bbls.	.....	Engineering	4th Qtr., 1958	.....	UOP	.....
Tidewater	Associated, Calif.	Platinum Cat. Reformer	22,500 bbls.	.....	Under Constr.	March, 1958	.....	Bechtel	Bechtel
		Steam Generating Plt.	.....	.....	.....	3rd Qtr., 1958	.....	Bechtel	Bechtel
Union Oil	Oleum, Calif.	Crude Topping Plt.	.....	.....	Complete	.....	.....	E & A	E & A
U.S. Oil & Refining	Tacoma, Wash.	Refinery	15,000 lbs.	.....	Under Constr.	1957	UOP	J. B. Gill	J. B. Gill
		Houdriformer	2,500 bbls.	.....	Complete	.....	Houdry	Holmes & Narver	Holmes & Narver
OUTSIDE U.S.A.									
Alaska & Hawaii									
Alaska-Yukon Refinery	Haines	Refinery	7,500 bbls.	$6,000,000	Engineering	1958	.....	Treco	Treco
Standard Oil (Calif.)	Honolulu	Refinery	35,000,000 bbls.	$40,000,000	Engineering	1959	.....	.....	.....
Canada									
Ajax Petroleum	Morinville, Alberta	*Gasoline Plt.	20 MMcf	$150,000	Complete	.....	.....	Mannix-Gill Co., Ltd.	.....
British American Oil	Clarkson, Ont.	Crude Exp.	40,000	$5,500,000	Complete	.....	.....	Kellogg	Kellogg
		Offsite Facilities	.....	$4,000,000	Under Constr.	.....	.....	Fluor	Fluor
	Edmonton	Cat. Reformer	4,000 bbls.	$1,500,000	Engineering	Early 1958	.....	Lummus	Lummus
		Cat. Desulfurization	6,300 bbls.		Engineering	Early 1958	Atlantic	Lummus	Lummus
	Pincher Creek	Sulfur Recovery	225 tons	.....	Under Constr.	1957	.....	Parsons	Parsons
	Port Moody	Refinery	20,000 bbls.	.....	Engineering	Late 1958	.....	.....	Kellogg
British Petroleum	Near Montreal	Refinery	30,000 bbls.	$30,000,000	Planning	.....	.....	.....	.....
Canadian Husky Oil	Ft. William, Calgary	*Refinery Exp.	.....	$700,000	Under Constr.	.....	.....	.....	.....
Canadian Hydrocarbons, Ltd.	Winnipeg, Man.	Fertiliser Plt.	600 tons	$18,500,000	Planning	.....	.....	.....	.....
Canadian Industries, Ltd.	Millhaven, Ont.	Anhydrous Ammonia	200 tons	$9,000,000	Under Constr.	Late 1957	.....	.....	.....
	Edmonton, Alberta	*Inc. Polythene	40,000,000 lbs./yr.	.....	Under Constr.	1959	.....	.....	Poole Constr. Co., Ltd.
Canadian Oil Co's., Ltd.	Corunna	Platformer; Udex	4,400 bbls. 3,650 bbls.	$3,000,000	Complete	.....	UOP	UOP; Fluor	Fluor
Canadian Petrofina	Montreal	Increase Cap.	30,000 bbls.	$3,000,000	Planning	2nd Half 1958	.....	.....	.....
Cities Service	Toronto	New Refinery	20,000 bbls.	$22,000,000	Engineering	.....	.....	Braun, Ltd.	Braun, Ltd.
Dow of Canada	Sarnia	Exp. Ethylene Plt.	.....	$4,000,000	Under Constr.	Fall, 1957	.....	Staff	Canadian; Bechtel; Stearns-Roger
Du Pont	Maitland, Ont.	Orlon Plt.	.....	.....	Planning	.....	.....	.....	.....
Excelsior Refineries	The Pas, Manitoba	Refinery	2-3,000 bbls.	$1,500,000	Planning	.....	.....	.....	.....
Goodrich, Canada	Welland, Ont.	Polyvinyl Geon	.....	$3,500,000	Complete	.....	.....	McKee	McKee
Imperial Oil	Sarnia	Detergent Alkylate	.....	$5,000,000	Under Constr.	Fall, 1957	.....	Fluor	Fluor
		Petrochemical Plt.	.....	$28,500,000	Under Constr.	Summer, 1958	.....	Canadian Bechtel	Canadian Bechtel
	Ioco, B.C.	Powerformer Prefractionator, Hydrofiner	5,000 bbls.	$4,000,000	Under Constr.	Dec., 1957	Esso	Bechtel: Staff	Bechtel
	Winnipeg	Add. Crude Cap.	2,500 bbls.	$4,500,000	.....	.....	.....	.....	.....
		Powerformer	2,850 bbls.		Under Constr.	Early 1958	.....	.....	Foster Wheeler
	Calgary	Refinery Exp.	18,400 bbls.	$17,000,000	Engineering	.....	.....	.....	.....
	Smiley-Coleville area, Sask.	*Gasoline Plt.	3 MMcf	$500,000	Complete	.....	Brown & Root, Inc.	Brown & Root Ltd.	Brown & Root, Ltd.
Jefferson Lake Sulphur	Taylor Flats, B.C.	Sulfur Recovery Plt.	425 tons	$1,800,000	Under Constr.	Fall, 1957	.....	Parsons	Parsons

* First appearance in tabulation † Added capacity

Construction BOXSCORE Continued on Page 213

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Two complete packaged remote control systems are now available for application to distant motor operated valves and electric pump motors. Gardtrol Valve and Pump Motor Monitors provide constant monitoring and positive, non-ambiguous indication of "on", "off", "open", "closed" and "stopped" conditions at remote stations. Both units feature simplified design—three components, a control unit, field unit and single wire transmission line provide efficient, economical controlling. Exclusive Gardtrol circuit utilizes the cyclically-reversing polarity of alternating current to effect both control and supervision over one wire. Distance is limited only by the resistance of the signal wire.

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opens, closes or stops valves in any position

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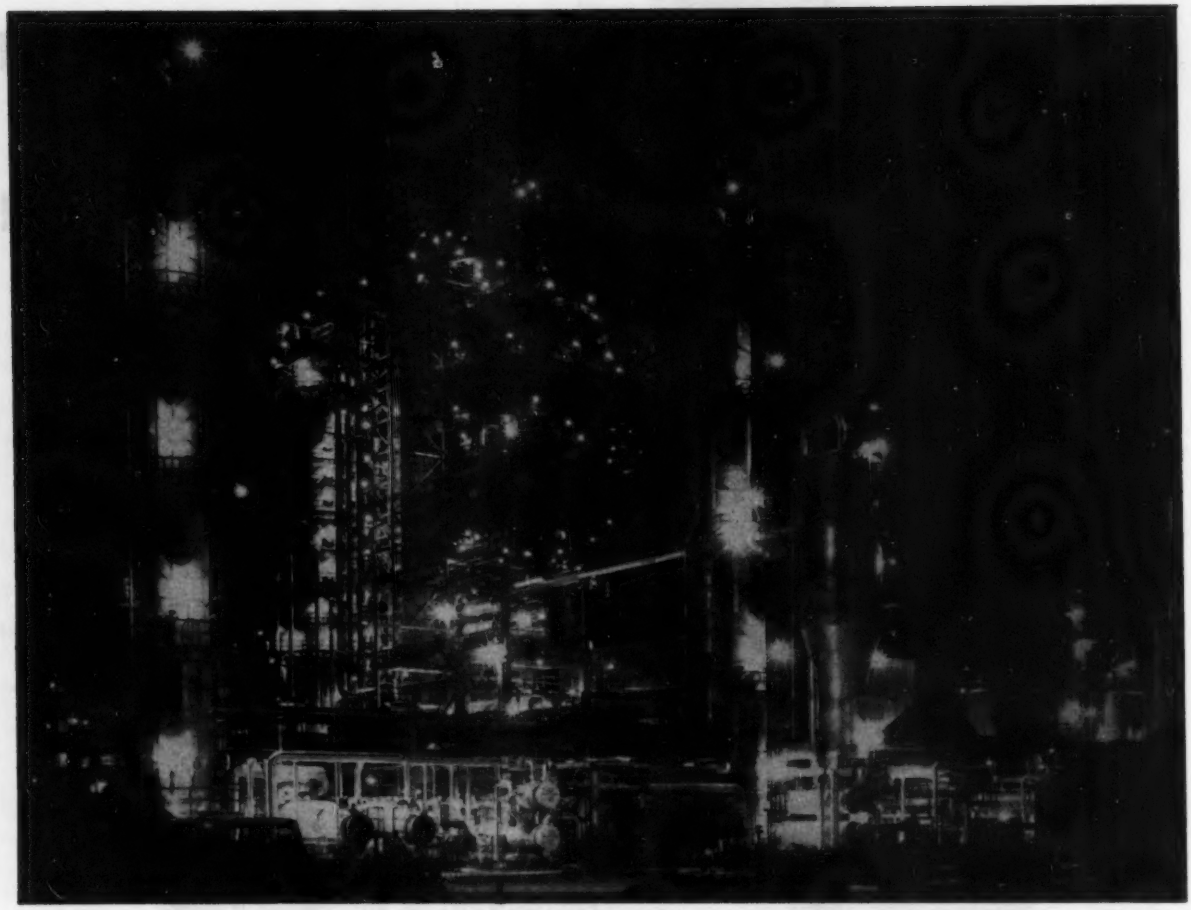

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Separator/Filters have multiple uses

Applications — In today's modern refineries and petrochemical plants, many processes are highly dependent upon low-cost removal of water and solid contaminants. Fram-Warner Lewis water separator/filters are extensively employed in process applications because their use provides the benefits of improved feed preparation, reduction in catalyst consumption, lower corrosion rates, and water free products.

Products Handled — LPG, gasoline, naphtha, distillate, gas oil, aromatics.

Special Uses—Feed stocks, treated and water-washed products, finished products to storage.

Description — Fram-Warner Lewis separator/filters offer a flexibility of design to meet a variety of process applications — Vertical single stage, horizontal single stage, horizontal two stage separator/filters with entrained water removal efficiencies of 90 to 100% and filtration efficiency down to 5 microns particle size. Engineering design and pressure vessel fabrication facilities at Warner Lewis Tulsa plant are always available to handle special problems to customer specifications. Let proven experience in the field in countless process applications help you.

For Further Information — Write Process Section Warner Lewis Company, Division of Fram Corporation, Box 3096, Tulsa, Oklahoma, for Process Manual on water separators/filters. Warner Lewis representatives are located throughout the United States and Canada and they will be glad to contact plant processing and operating personnel. (Adv.)

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
McColl-Frontenac	Montreal East	Hydrotreater	10,000 bbls.	$1,000,000	Under Constr.	Early 1958	Texas Co.	Foster Wheeler	Foster Wheeler, Ltd.
Midland Pet. & Pacific Pet.	Stettler, Alta.	Crude Refinery	4,000 bbls.	$2,000,000	Under Constr.	.....	.....	.....	.....
Pacific Petroleum	Fort St. John, B.C.	Gas-Absorption Plt.	.....	$18,000,000	Planning	.....	.....	.....	.....
Pacific Petroleum & Phillips Petroleum	Taylor, B.C.	Refinery Expansion	.....	.....	Under Constr.	Late 1957	.....	Stearns-Roger	Stearns-Roger
Quebe Ammonia	Montreal	Ammonia Nitric Acid—80 tons Nitrogen Solutions	120 tons	$8,000,000	Planning	.....	Texaco	.....	.....
Regent Refining	Port Credit, Ont.	Fluid Cat Cracker, Vacuum Distillation, Gas Polymerization	.....	$5,500,000	Complete	.....	.....	Procon	Procon
Royalite Oil	Kamloops, B.C.	Platformer	1,000 bbls.	$750,000	Under Constr.	March, 1958	UOP	UOP	Treco
B. A. Shawinigan	Montreal, East	Exp. Phenol Plt.	.....	.....	Complete	.....	.....	Staff	Staff
Shell Oil (Canada)	Bronte, Ont.	Refinery	.....	.....	Considering	.....	.....	.....	.....
	Montreal,	HF Alkylation	1,500 bbls.	$4,000,000	Under Constr.	1958	UOP	UOP Treco, Staff	Treco
	Quebec	Tetramer Unit	.....	.....	Under Constr.	1958	.....	Treco, Staff	Treco
		Resin Plt.	.....	$1,000,000	Under Constr.	Early 1958	.....	Treco, Staff	Treco
	Cochrane, Alberta	*Exp. Treating Plt.	.....	.....	Under Constr.	.....	.....	.....	.....
Sherritt-Gordon Mines, Ltd.	Fort Saskatchewan, Alta.	Anhydrous Ammonia	75 tons	$24,000,000	Planned	.....	.....	.....	.....
Union Carbide, Canada	Montreal East, Quebec	Ethylene Glycol & Polyethylene Exp.	.....	$4,000,000	Under Constr.	Early 1958	.....	Staff	.....
LATIN AMERICA									
Brazil									
Alba (Borden)	Cubatao	Methanol, Formaldehyde, Synthetic Resins	30 tons	$3,500,000	Engineering	1958	Vulcan	Vulcan Girdler	Staff Girdler
Petroleo Brasileiro	North Brazil	Refinery	25,000 bbls.	.....	Studying	.....	.....	.....	.....
	South Brazil	Refinery	70,000 bbls.	.....	Studying	.....	.....	.....	.....
	Cubatao	Ethylene Recovery Unit	40,000,000 lbs./yr.	.....	Under Constr.	Fall 1957	.....	Hydrocarbon, Edeleanu	Staff
	Mataripe	Atmospheric & Vacuum Distil. Units, Cat. Crkr, Gas Recovery, Wax Treating	37,000 bbls.	.....	Engineering	Mid 1959	Kellogg	Kellogg	Kellogg
	Rio de Janeiro	New Refinery	90,000 bbls.	$60,000,000	Engineering	Early 1960	.....	Foster Wheeler	.....
Uhde	Cubatao	Urea Plt.	.....	.....	.....	.....	.....	Uhde	Uhde
Union Carbide	Cubatao	Polyethylene	.....	.....	Under Constr.	Early 1958	.....	Brown & Root	Brown & Root, Ltd.
Colombia									
Empresa Colombiana de Petroleos	El Centro	Plt. Modernization	2,000 bbls.	$3,000,000	Engineering	1958	.....	Parsons	Parsons
	Barranca Bermeja	Exp. Propane Recovery	1,000 bbls.	$1,000,000	Planning	.....	.....	.....	.....
International Petroleum (Colombia), Ltd.	Cartagena	Refinery	26,500 bbls.	$32,500,000	Under Constr.	Late 1957	Esso	Bechtel	Bechtel
Cuba									
Esso Standard	Havana	Ref. Expan.; Distillation, Polymerization, Powerforming, Cat. Cracking	To 35,000 bbls.	$30,000,000	Under Constr.	Late 1957	Esso	McKee	McKee
Refinadora Cabaiguan	Cabaigun, Cuba	Ref. Expan.	.....	.....	Planning	.....	.....	.....	.....
The Texas Co.	Santiago	Refinery	20,000 bbls.	$14,000,000	Under Constr.	1957	.....	.....	.....
Mexico									
Celanese Mexicana, S.A.	Mexico City	Formaldehyde; Synthetic Resin	.....	.....	Under Constr.	.....	.....	.....	.....
Central Minera, S.A.	Tenixtepec, Mex.	Sulphur Plt.	1,000 tons	$3,500,000	Under Constr.	March, 1958	.....	.....	.....
Pemex	Mexico City	Cat Cracking, Gas Concentration, HF Alkylation; Polymerization; Ethylene; Sulfur	25,000 bbls.	$12,500,000	Under Constr.	Late 1957	Esso-Phillips, U.O.P.	McKee	Staff
	Pemex City	Nat. Gaso. Plt.	300 Mmcf	$7,400,000	Complete	.....	.....	Hudson	Staff
	Cuidad Madero	Topping	100,000 bbls.						
		Cat. Cracking	25,000 bbls.						
		Gas Concentration; HF Alkylation; Polymerization; Sulfur Plt.		$25,700,000	Under Constr.	Mid 1958	Phillips, Esso, UOP	McKee	Staff
	Minatitlan	Combination Distill.; Clay Treating; Lube Oil	6,500 bbls.	$2,500,000	Under Constr.	Late 1957	.....	Fluor	Staff
	Salamanca	Grease Plt.	25 tons	$1,700,000	Engineering	1957	.....	McKee	Staff
		Cat. Cracker	15,000 bbls.	.....	Planning	.....	.....	.....	.....
	Poza Rica	Topping Plt.	10,000 bbls.	$1,350,000	Engineering	.....	.....	Staff	Staff
Netherlands Antilles									
N. V. Curacaosche Petro. Ind, Mij.	Curacao	Feed Prep. (2)	33,000 bbls.	$7,000,000	Under Constr.	Late 1957	.....	Badger	Werkspoor, N.V.
			33,000 bbls.	$7,000,000		End 1957	.....	Badger	Werkspoor, N.V.
		Cat. Cracker	33,000 bbls.	.....	Under Constr.	Late 1957	.....	N. V. De Bataafsche Pet. Mij.	Werkspoor N.V.
Panama									
Refinera Petroquimica de Panama	Colon	Refinery	55,000 bbls.	$33,000,000	Engineering	.....	.....	Foster Wheeler	Foster Wheeler
Refineria Panama	Las Minas Bay, Coson	Refinery; Petrochemicals	70,000 bbls.	$59,000,000	Under Constr.	1959	.....	Pet. Comb. & Eng. Co.	Pet. Comb. & Eng. Co.
Peru									
Fertiza Limitada	Peru	Fertilizer Plt.	.....	.....	Planning	1957	.....	Montecatini	.....
Helios, S.A.	San Andres	Fertilizer Plt.	130,000 tons	.....	Planning	.....	.....	.....	.....
Puerto Rico									
Commonwealth Oil Refining Co.	Guayanilla Bay	Refinery	30,000 bbls.	$16,000,000	Complete	.....	.....	.....	Lummus
Union Carbide Caribe Trinidad	Ponce	Ethylene-Glycol	500,000 lbs	$28,500,000	Planning	Mid 1958	.....	Brown & Root	Brown & Root
W. R. Grace & Co.	Trinidad	Chemical Plt.	.....	$10,000,000	Planning	.....	.....	.....	.....

* First appearance in tabulation † Added capacity

Construction BOXSCORE Continued on Page 214

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licenser	Engineering	Contractor
Venezuela									
Cia. Shell de Venezuela	Cardon	Cat Cracker	33,000 bbls.	.....	Complete	.....	.....	.....	.....
		Polymerization; Treater, Feed Preparation	.....	.....	Under Constr.	.....	.....	H.W.P.	.....
		Distillation	80,000 bbls.	$20,000,000	Under Constr.	4th Qtr., 1958	.....	.....	.....
		Alkylation	2,300 b'ls.	.....	Under Constr.	1st Qtr., 1958	.....	.....	.....
Creole Pet. Corp.....	Amuay Bay	Pipe Still	70,000 bbls.	$10,800,000	Complete	.....	.....	Foster Wheeler	Foster Wheeler
		Distillation	105,000 bbls.	$7,150,000	Complete	.....	.....	Foster Wheeler	Foster Wheeler
	Amuay Bay	Hydrofining Plt.	17,000 bbls.	$3,000,000	Under Constr.	Dec., 1957	.....	Foster Wheeler	Foster Wheeler
		Lube Oil Plt.	700 bbls.	$7,650,000	Under Constr.	May, 1958	Esso	Foster Wheeler	Foster Wheeler
	Lake Maracaibo	LPG Plt.	17,000 bbls.	$11,173,000	Engineering	Jan., 1958	Creole	Tellepsen	.....
Venezuelan Govt.....	Venezuela	Ammonia Synthesis Gas	120 tons	$1,000,000	Planning	1957	.....	Air Products	Air Products
EUROPE AND AFRICA									
Belgium									
Esso Standard.....	Antwerp	Vac. Distill.	2,900 bbls.	$750,000	Engineering	Early 1958	.....	Badger-Comprimo	Badger-Comprimo
		Powerformer	5,600 bbls.	$7,100,000	Under Constr.	Early 1958	.....	Badger-Comprimo	Badger-Comprimo
		Hydrofiner	6,900 bbls						
Petrochim.....	Antwerp	Ethylene Oxide, Ethylene Glycol	.....	$8,000,000	Under Constr.	4th Qtr., 1957	Scientific Design	Scientific Design	.....
Raffinerie Belge de Petroles	Antwerp	Cat. Reformer and Feed Desulfurization	2,500 bbls.	$2,000,000	Complete	.....	Sinclair-Baker	KIC	KIC
Soc. Industrielle Belge de Petroles	Antwerp	Cat. Reformer	10,000 bbls.	.....	Under Constr.	Early 1958	.....	Kellogg; UOP	Kellogg
		Hydrofiner	10,000 bbls.	.....	Under Constr.	Early 1958	.....	Kellogg	Kellogg
Egypt									
Anglo-Egyptian Oilfields	Suez	Cat. Reformer	2,300 bbls.	.....	Projected	1957	.....	.....	.....
Egyptian Govt.....	Suez	Power Plt.	10,000 KW.	$2,200,00	Planned	1959	.....	Italian	Firms
		Mech. Workshop	.....	$1,000,000	UnderConstr.	Jan., 1958	.....	.....	Local
		Cooling Tower. & Accessories	5,000 tons	$250,000	Complete	.....	.....	Local	Local
		Atmos. Dist., Vac. Dist. & Lube Oils	20,000 bbls.	$7,000,000	Planning	1960	.....	.....	.....
		Vapor Recovery & Bottling	70 tons	$1,000,000	Planned	1959	.....	Lummus	Lummus
	Alex	*Atmos. & Vac. Dist.	10,000 bbls.	$1,400,000	Planning	.....	.....	.....	.....
	Cairo	*Atmos. Dist. & Vac. Dist.	10,000 bbls.	$1,400,000	Planning	.....	.....	.....	.....
England									
Berry, Wiggins & Co., Ltd.	Weaste Ref., Manchester	Extension to Refinery	1,600 bbls.	.....	Complete	.....	.....	H.W.P.	H.W.P.
British Petroleum....	Kent	Hydrofiner I	10,000 bbls.	.....	Under Constr.	Late 1957	.....	Kellogg	
		Hydrofiner II	10,000 bbls.	.....	Under Constr.	Mid 1958	.....	Kellogg	McAlpine, Wimpey
		Stabilizer	12,000 bbls.	.....	Under Constr.	Late 1957	.....	Power Gas Corp.	McAlpine, Wimpey
		Absorption and Regeneration Units	.....	.....	Under Constr.	Late 1957	.....	Kellogg	McAlpine, Wimpey
		Sulfur Recovery Plt.	45 tons	.....	Under Constr.	End 1957	.....	Simon-Carres	McAlpine, Wimpey
		Two Copper Chloride Units	8,000 bbls, ea.	.....	Under Constr.	Early 1958	.....	W. J. Fraser	McAlpine, Wimpey
		Alkylation Plt.	2,250 bbls.	.....	Under Constr.	Early 1958	.....	Lummus	
		Distillation Unit	90,000 bbls.	.....	Under Constr.	Late 1957	.....	Badger, Ltd.	McAlpine, Wimpey
		Cat. Reformer	10,000 bbls.	.....	Under Constr.	Early 1958	.....	UOP, Kellogg	
		Thermal Reforming	12,000 bbls.	.....	Under Constr.	Mid 1958	.....	Kellogg	
Eastern Gas Board...	Bedford	Oil Gasification	2,000,000 cu. ft.	.....	Complete	.....	.....	H & G	H & G
	Dunstable	Oil Gasification	6,000,000 cu. ft.	.....	Planning	Spring 1958	.....	H & G	H & G
East Midlands Gas Board	Sheffield	Oil Gasification	10,000,000 cu. ft.	.....	Under Constr.	Nov., 1957	.....	H & G	H & G
	Northampton	Oil Gasification	6,000,000 cu. ft.	.....	Planning	Dec., 1957	.....	H & G	H & G
Esso Petroleum Co....	Fawley	Ethylene & Butadiene Plt.	.....	$27,000,000	Engineering	Mid, 1958	.....	Foster Wheeler	Foster Wheeler
		Hydrofiner	12,000 bbls.	$2,750,000	Complete	.....	.....	Foster Wheeler	Foster Wheeler
		Sulfur Plt.	60 tons	$700,000	Engineering	1st Qtr., 1958	.....	Foster Wheeler	Foster Wheeler
		Crude Pipestill	70,000 bbls.	$5,000,000	Under Constr.	4th Qtr., 1957	.....	Foster Wheeler	Foster Wheeler
	Milford Haven	Refinery	100,000 bbls. yr.	$56,000,000	Planning	Early 1960	.....	.....	.....
Hedon Chemicals.....	Hedon, Yorks...	Vinyl Acetate	.....	.....	Under Constr.	.....	.....	.....	.....
International Synthetic Rubber	Fawley	Synthetic Rubber	50,000 ton/yr.	$12,000,000	Engineering	1957	.....	Blaw Knox	Blaw Knox
Mobil Oil Co., Ltd....	Coryton	Cat. Hydrodesulfurization	.....	.....	Pre-engineering	.....	.....	.....	.....
		Crude Unit Exp.	5,000 bbls.	.....	Under Constr.	1st Qtr., 1958	.....	Staff	Staff
Monsanto Chemicals..	Britain	Add Polystyrene	.....	.....	Under Constr.	.....	.....	Staff	Staff
		Styrene-Butadiene Copolymer Plt.	4,000 ton/yr.	$14,000,000	Planned	.....	.....	.....	.....
North Thames Gas Board	Romford	Oil Gasification	4,000,000 cu. ft.	.....	Complete	.....	.....	H & G	H & G
		Refinery Tail Gas Reforming	36,000,000 cu. ft	.....	Under Constr.	March, 1958	.....	H & G	H & G
Regent Oil.....	Southern England	Refinery	.....	.....	Planning	.....	.....	.....	.....
Shell Chemical.....	Shell Haven	Ammonia; Nitric Acid	75,000 tons/yr.	$18,500,000	Planning	1958	.....	.....	.....
		Fertilizer	.....	$12,500,000	Planning	.....	.....	.....	.....
	Partington	Ethylene Oxide	25,000 tons/yr.	.....	.....	Mid, 1958	.....	.....	.....
Shell Refining.....	Shell Haven	Atmospheric Distil.	80,000 bbls.	.....	Under Constr.	Late 1958	.....	S&W; E.B. Badger, Ltd.	E. B. Badger Ltd.
South Eastern Gas Board	Isle of Grain	Oil Gasification	15 Mmcf	.....	Under Constr.	Fall, 1958	.....	Power Gas	Power Gas
		Segas Cat. Oil-Gas Unit	20,000,000 CF	.....	.....	1958	.....	Power Gas Corp.	.....
Southern Gas Board..	Southampton	*Refinery Tail Gas Reforming	16 MMcf	.....	Under Constr.	Oct., 1958	.....	H & G	H & G
France									
Cabot France S.A.....	Berre-L'Etang	Carbon-Black Plt.	150,000 lbs.	$4,000,000	Under Constr.	1957	Cabot	Staff	CITRA
Caltex S. A. F.....	Ambes	Cat. Cracker	4,700 bbls.	.....	Under Constr.	1957	.....	Lummus	Lummus
		Vacuum Unit	6,600 bbls.	.....	Under Constr.	1957	.....	Lummus	Lummus
Compagnie de Raffinage Shell Berre	Petit Couronne	Distill. Unit	80,000 bbls.	.....	Planned	3rd Qtr., 1958	.....	.....	.....
Comp Francaise de Raffinage	Provence	Desulfurization	12,000 bbls.	.....	Complete	.....	.....	KIC	KIC
		Powerformer	20,000 bbls.	.....	Under Constr.	Mid 1958	.....	Foster Wheeler	Foster Wheeler
	Normandie	Ethylene Plt.	30,000 tons/yr.	.....	Engineering	1958	.....	KIC	.....

* First appearance in tabulation † Added capacity

Construction BOXSCORE Continued on Page 217

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Workmen applying Thermobestos insulation to an expansion loop in a process line.

Specify

J-M THERMOBESTOS® the heat insulation designed for outdoor process industries

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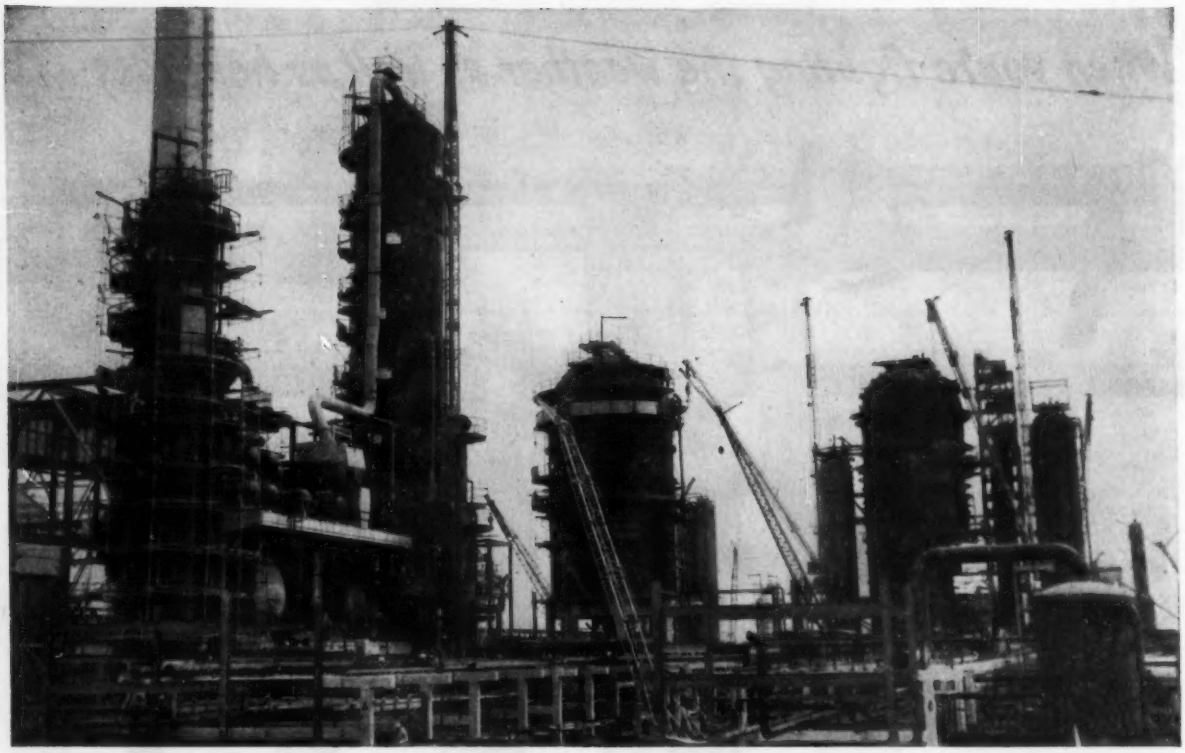


A dozen vessels built by Newport News were furnished under contract with C. F. Braun, Inc., of Alhambra, Calif., design engineers for the ultra-modern Delaware Flying A Refinery of the Tidewater Oil Company located 15 miles south of Wilmington.

Newport News builds 12 major components for new Flying A 130,000-bpd refinery

This is the Tidewater Delaware Flying A Refinery while under construction near Wilmington.

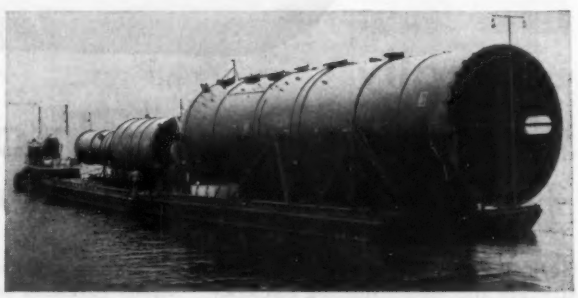
Newport News fabricated 12 of its major vessels — 2 of which are the largest such units ever built: a 250′ Orthoflow fluid "cat cracker" converter and a 225′ reactor scrubber of the fluid coker.

More notable than size, though, is the quality of the Newport News fabrication.

Coke-out screens in the reactor scrubber, for example, are made of 704 12% chromium segments. Welded together with accuracy, they provide 45% clear opening . . . with opening tolerances less than 1%.

You get expert fabrication, the skill of specialists when Newport News builds your equipment. When you want reactors, pressure vessels, vacuum tanks and the like, sub assemblies or weldments in almost any size or shape, get a bid from Newport News.

Send for newly published, easy-to-read, illustrated booklet, "Facilities and Products". It describes the many ways in which Newport News can help you with present or future projects. Write for your copy today.



Full advantage was taken of the Newport News deep water loading facilities for transportation of all of the equipment by barge. Shop erection prior to shipment assured fast, trouble-free field assembly.

Engineers: Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.

Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Comp. Francaise des Matieres Colorantes	France	Maleic-Anhydride	.....	.....	Complete	.....	Scientific Design	Scientific Design	.....
Esso Standard.....	Gironde Bordeaux	Refinery	31,500 bbls. Expandable to 45,000 bbls.	.....	Planning	1959	Esso	Lummus	Lummus
	Port Jerome	Cat. Cracker	10,000 bbls.	$11,000,000	Planning	1957	.....	Foster Wheeler	Foster Wheeler
		Powerformer	.....	.....	Under Constr.	2nd Qtr., 1958	Esso	Foster Wheeler	Foster Wheeler
Houilleres du Bassin de Lorraine	Carling	Acetylene Plt.	.....	.....	Under Constr.	.....	Koppers	SBA	SBA
		Styrene Monomer	.....	.....	Under Constr.	.....	.....	SBA	SBA
Lorraine-Kuhlmann....	Dieuze (Moselle)	*Polystyrolene	.....	.....	Under Constr.	.....	Koppers	Kuhlman	.....
Manufacture Normande de Polyethylene	Gonfreville	Polyethylene	.....	.....	Under Constr.	.....	Phillips	.....	S.T.E.C.
Marles-Kuhlmann....	Gonfreville	*Ethylene Oxide	.....	.....	Under Constr.	.....	Scientific Design	Staff	.....
Mobil Oil Francaise..	Gravenchon	Cat. Hydrosulfurisation	5,000 bbls.	.....	Complete	.....	.....	Staff	.....
		Lube Exp.	.....	.....	Constr. 1st phase Engineering 2nd phase Planning 3rd phase	4th Qtr., 1957 1958 1959	.....	.....	.....
Naphtachimie.....	Lavera	Exp. Ethylene Oxide	.....	.....	Under Constr.	4th Qtr., 1957	Scientific Design	Scientific Design	.....
		Expand Ethylene	.....	.....	Under Constr.	1957	.....	S&W, E.B. Badger, Ltd.	.....
Pechiney.....	St. Auban	Perchlorethylene Plt.	.....	.....	Complete	.....	Scientific Design	Scientific Design	.....
Potasse et Engrais Chimiques	Grand Couronne	Ammonia	.....	.....	.....	.....	SBA	KIC	KIC
Shell-Berre.....	Berre	Furfural Unit	3,500 bbls.	.....	.....	.....	.....	Foster Wheeler	Foster Wheeler
Societe du Caoutchouc Butyl	Port Jerome	Butyl Rubber Plt.	20,000 tons/yr.	.....	Under Constr.	Fall 1958	ESSO	Braun	Braun
Soc. Francaise des Petroles BP	Dunkirk	Cat. Reformer	10,000 bbls.	.....	Under Constr.	Early 1958	.....	UOP; Kellogg	.....
	Lavera	Distillation	50,000 bbls.	.....	Under Constr.	Late 1957	.....	Foster Wheeler	Foster Wheeler
Soc. Nationale des Petroles D'Aquitaine	Lacq	Desulfurization	†140 MMcf	.....	Under Constr.	Mid 1958	.....	Foster Wheeler	Foster Wheeler
		Distill. Recovery with Prod. Treat. & Fract.	90 MMcf	.....	Engineering	Mid 1958	.....	Hydrocarbon	Hydrocarbon
		*Sulfur Recovery	†780 tons	$22,000,000	.....	.....	.....	Parsons, Houdry	.....
West Germany									
Badische Anilin und Soda Fabrik A G	Ludwigshafen	Polyethylene	.....	.....	Licensed	.....	Phillips	.....	.....
B P Benzin und Petroleum	Hamberg-Finkenwerder	Hydrofiner	6,500 bbls.	.....	Complete	.....	.....	Uhde	.....
Buna Werke Hule G.m.b.H.	Marl, Kreis Recklinghausen, Western Germany	Synthetic Rubber Plt.	45,000 tons/yr.	$37,000,000	Under Constr.	Summer 1958	Esso R&E; Houdry; Firestone	Staff	Staff
Deutsche Erdohle....	Bremen	Cat. Poly Revamp	.....	.....	Engineering	.....	Calif. Res. Hydrocarbon	Hydrocarbon, Hydro M	Staff
Deutsche Shell.....	Harburg	Cat. Reformer Crude Distiller Cat. Reformer Hydrodesulfurization	40,000 bbls.	.....	Under Constr.	1st Qtr., 1959	.....	.....	.....
	Godorf	Refinery	80,000 bbls.	.....	Planning	1960	.....	.....	.....
Esso A.G.....	Cologne	Refinery	72,000 bbls.	$39,000,000	Engineering	Jan., 1959	Esso	Braun & Others	Braun & Others
		Atmospheric Crude Distl.	.....	.....	.....	.....	.....	Braun, Uhde	.....
		Powerformer	9,000 bbls.	.....	.....	.....	.....	Lurgi G.H.H.	.....
		Gas-Oil Hydrofiner	12,000 bbls.	.....	.....	.....	.....	G.H.H.	.....
		Steam Cracker	5,600 bbls.	.....	.....	.....	.....	Kocha Still	.....
		Sulfur Recovery	8,900 tons/yr.	.....	.....	.....	.....		.....
Farbenfabriken Bayer A.G.	Dormagen	Crude Oil Cracking Plt.	.....	.....	.....	Fall, 1958	Lurgi	.....	.....
		*Ethylene Oxide	26 MM lbs./yr.	.....	Under Constr.	1958	Scientific Design	Scientific Design	.....
Farbwerke Hoechst A.G.	Hoechst	Acetaldehyde	11,000 tons/yr.	.....	Complete	.....	.....	Uhde	Uhde
		Propane-Propylene Separation	.....	.....	Complete	.....	.....	Uhde	Uhde
Feldmuhle.....	Luladorf	Ethylene	10,000 tons/yr.	.....	Engineering	End 1958	.....	Hydrocarbon Hydro M	Hydro M
Kohle-Oil Chemie....	Gelsenkirchen	Polyethylene	24,000 tons/yr.	.....	Planning	.....	.....	.....	.....
Mobil Oil A.G.....	Bremen Oslebhausen	Crude Two Stage	16,000 bbls.	.....	Under Constr.	2nd Qtr., 1958	.....	Hydrocarbon Hydro M	Hydro M
Purfina Mineralol-raffinerie A.G.	Duisburg	Topping, Platformer Hydrodesulfurizer	20,000 bbls.	.....	Under Constr.	Mar., 1959	UOP, Shell	Lummus	Lummus
Rheinische Olefinwerke	Bex. Koln, Germany	*Exp. Polyetyhlene Plt.	.....	$33,000,000	.....	Late 1958	.....	.....	.....
Ruhrbau.....	Mulheim	Refinery	15,000 bbls.	.....	Planning	.....	.....	.....	.....
Ireland									
Chemstrand.....	Northern Ireland	Acrylic Fiber Plt.	10,000,000 lbs./yr.	$10,000,000	Engineering	Dec., 1958	.....	Costain John Brown, Ltd., Staff	Costain John Brown, Ltd.
Irish Refining Co..... Esso Petr. (Ireland) Caltex (Ireland) Shell Mex., B.P.	Whitegate	Refinery	32,000 bbls.	$33,600,000	Approved	1959	.....	.....	.....
Italy									
Asienda Nazionale Idrogenazione Combustibil	Ravenna	Styrene Monomer Plt.	14,000 tons/yr.	.....	Engineering	.....	Koppers	SBA	SBA
Destillerie Italiane....	Milano	Butanol	11,000 tons/yr.	.....	Engineering	.....	Hoechst	Uhde	Uhde
Ente Nazionale Idrocarburi	Ravenna	Butadiene Plt.	30,000 tons a yr. Rubber	$75,000,000	Under Constr.	1957	.....	Union Carbide Carbon;	Brown-Root
		Copolymer Plt.	350,000 tons a year		Under Constr.	1957	.....	Phillips Petroleum	Brown-Root
		Ammonia; Fertilisers	.....		.....	1957	.....	.....	.....
Esso Standard Italiana	Trieste	Powerformer	1,000 bbls.	$930,000	Complete	.....	Esso	Esso C.T.I.P.	C.T.I.P.
Golfo Industria Petrolifera, A.P.A.	Gaeta, Italy	New Refinery	15,000 bbls.	.....	.....	.....	.....	Tecnider	.....
Islom.....	Palermo	Refinery	15,000 bbls.	.....	Planning	1958	.....	Staff	.....
Mobil Oil Italiana S. p.a	Naples	Cat. Reforming	9,000 bbls.	.....	Under Constr.	Oct., 1958	.....	CTIP	CTIP
		Cat. Hydrodesulfurisation	10,000 bbls.	.....	Under Constr.	Oct., 1958	.....	CTIP	CTIP
		Lube Expansion	.....	.....	Under Constr.	Oct., 1958	.....	Staff	Staff

* First appearance in tabulation † Added capacity

Construction BOXSCORE Continued on Page 218

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Raffineria Siciliana Oli Minerali (RASIOM)	Augusta	Powerformer	7,500 bbls.	$2,000,000	Complete	.....	Esso	CTIP	Bonaldi-Crema
Shell Italiana.....	Palermo	Refinery	20,000 bbls.	.....	Planning	.....	.....	.....	.....
Soc. Solvay & Cie....	Italy	Polyethylene	.....	.....	Licensed	.....	Phillips	.....	.....
STANIC Industria Petrolifera	Bari	Powerformer	7,300 bbls.	$3,400,000	Complete	.....	Esso	CTIP	CTIP
		Hydrofiner	8,200 bbls.	$850,000	Engineering	June, 1958	Esso	CTIP	CTIP
	Livorno	Hydrofiner	8,200 bbls.	$1,000,000	Engineering	August, 1958	Esso	CTIP	CTIP
Netherlands									
Caltex Petroleum Maatschappij N.V.	Pernis	Platformer	7,000 bbls.	.....	Under Constr.	1957	UOP	Lummus, Ltd.	Lummus-Werk-spoor
		Diesel Unifiner	4,000 bbls.	.....	Under Constr.	1957	UOP, Union	Lummus, Ltd., Parsons	Lummus-Werk-spoor
Esso Nederland.....	Rotterdam	Refinery	40,000 bbls.	$29,000,000	Planning	Early 1960	.....	.....	.....
Mekog.....	Velsen-Ymuiden	Nitrogen Fertilizer	.....	$9,000,000	Planning	.....	.....	.....	.....
Nederlandsche Dow Maatschappij N.V	Rotterdam	Processing Plt.	.....	.....	Planned	.....	.....	.....	.....
N.V. de Bataafsche Pet. Maatschappij	Pernis	Syn. Glycerine	.....	$7,000,000	Under Constr.	Late 1957	.....	.....	Staff
		Cat. Reformer	12,700 bbls.	.....	Under Constr.	2nd Qtr., 1958	.....	.....	.....
		Hydrodesulfuriser I	16,400 bbls.	.....	Under Constr.	2nd Qtr., 1958	.....	.....	.....
		Hydrodesulfuriser II	7,800 bbls.	.....	Under Constr.	2nd Qtr., 1958	.....	.....	.....
		Alkylation Plt.	2,800 bbls.	.....	Under Constr.	1st Qtr., 1958	.....	.....	.....
Norway									
Standard (N.J.).....	Oslo Fjord	Refinery	40,000 bbls.	$29,000,000	Negotiating	.....	.....	.....	.....
Portuguese W. Africa									
Petrofina.....	Luanda	Refinery	.....	.....	Planning	.....	.....	.....	.....
Scotland				Part of					
British Hydrocarbon Chemicals	Grangemouth	Butadiene	.....	.....	Under Constr.	.....	.....	KIC	KIC
		Polyethylene Plt.	25,000,000 tons/yr.	.....	Engineering	.....	Phillips	S&W; E. B. Badger, Ltd.	.....
Spain									
Hidro Nitro Espanola	Monzon	Ammonia Synthesis	22 tons	.....	Under Constr.	Late 1957	.....	Uhde	Uhde
Refineria de Petroleos de Escombreras S.A.	Escombreras	Topping Unit	25,000 bbls.	.....	Under Constr.	1957	.....	Foster Wheeler	Foster Wheeler
		Platformer	11,000 bbls.	.....	Under Constr.	1957	UOP	Foster Wheeler	Foster Wheeler
Turkey									
Badische Anilin and Soda Fabrik	Kutefia	Ammonium Sulfate	60,000 tons/yr.						
		Sulfuric, Nitric Acid	50,000 tons/yr.	$20,000,000	Planning	1958	.....	.....	.....
Mobil Overseas, Shell, Cal-Tex, BP	Turkey	Refinery	65,000 bbls.	$48,000,000	Planning	1960	.....	.....	.....
Turkish-American Oil.	Istanbul	Refinery; Crude-Vacuum; Cat. Crker., Vapor Recovery, Cat. Poly, Treating	15,000 bbls.	$18,000,000	Approved	Dec., 1958	.....	Kellogg	Kellogg
Turkish Government..	Istanbul	Natural Gasoline Plt.	.....	.....	Planning	.....	.....	.....	.....
Union of South Africa									
Standard-Vacuum....	Durban	Refinery Exp.	25,000 bbls.	$9,000,000	Engineering	.....	.....	Foster Wheeler	Foster Wheeler
		Powerformer	.....	.....	.....	.....	.....	.....	.....
		Hydrofiner	.....	.....	.....	.....	.....	.....	.....
		Steam Plt.	.....	.....	.....	.....	.....	.....	.....
Union Petrol Refinery Ltd.	Johannesburg	Refinery	.....	$20,000,000	Projected	.....	.....	.....	.....
NEAR EAST									
Aden									
British Petroleum....	Aden	Thermal Reformer	12,000 bbls.	.....	Under Constr.	1958	.....	KIC	Bechtel
Bahrain									
Bahrain Petroleum...	Bahrain	Platformer	10,000 bbls.	.....	Under Constr.	1957	UOP	Foster Wheeler	Foster Wheeler
Iran									
National Iranian Oil Co.	Kermanshah	Refinery Exp	6,850 bbls.	$3,627,000	Engineering	1958	NIOC	Costain-John Brown, Ltd.	.....
Iraq									
Iraq Government.....	Iraq	Lube Oil Plt.	25,000 tons/yr.	$12,000,000	Complete	.....	JUIK	Foster Wheeler	Foster Wheeler
	Daura	Refinery Expansion	50,000 bbls.	$15,000,000	Bids in	Late 1958	Texaco	.....	.....
	Baghdad	*Lube Oil Plt.	25,000 tons/yr.	$12,000,000	Complete	.....	.....	Foster Wheeler	Foster Wheeler
		*Refinery Exp. Powerformer Crude Unit	48,000 bbls.	$11,000,000	Under Constr.	July, 1959	Esso	Foster Wheeler	Foster Wheeler
Jordan									
ordanian Reconstruction Council	Mafrak	Refinery	.....	$7,500,000	Planned	.....	.....	.....	.....
Kuwait									
Kuwait Oil.....	Mina alAhmadi	Two Distillation Units	80,000 bbls. each	.....	Under Constr.	Early 1958	.....	S&W; E.B. Badger; Bechtel	Bechte
Saudi Arabia									
Arabian American Oil Co.	Ras Tanura	Hydrofiner	15,000 bbls.	$4,100,000	Under Constr.	Late 1957	Esso	Lummus	Bechtel
Syria									
Esso Standard.....	Syria	Refinery	10,000 bbls.	.....	Proposed	.....	.....	.....	.....
Syrian Government...	Homs	Refinery	20,000 bbls.	$11,000,000	Planning	.....	.....	.....	.....
FAR EAST									
Ceylon									
Shell of Ceylon.....	Hendola	Refinery	.....	$40,000,000	Planning	.....	.....	.....	.....
India									
Dow et al.....	Bombay	Polystyrene Plt.	2,700 ton/yr.	.....	Complete	.....	.....	Bechtel	Bechtel
Indian Government...	Bhavnagar	Refinery	30,000 bbls.	$42,000,000	Considering	.....	.....	.....	.....
	India	Synthetic Pet. Plt.	6,000 lbs.	.....	Planning	.....	.....	.....	.....
Japan									
Asahi Chem. Co., Ltd.	Nobeoka	Ammonia Plt.	50 tons	.....	Under Constr.	Autumn, 1958	.....	Chemico	Chemico
Befu Chemical.....	Befu Harbor Honshu	Ammonia Plt.	.....	.....	Under Constr.	.....	Texaco	Chemico	Chemico
Daikyo Oil.....	Yokkaichi	Houdriformer	3,000 bbls.	.....	Under Constr.	Late 1957	Houdry	Treco	Staff
Daikyo Oil (Continued)	Yokkaichi	Lube Oil Furfural Unit	.....	.....	.....	.....	Texaco	.....	.....
Furukawa Chemical Industries	Japan	Polyethylene	.....	.....	Approved	.....	Phillips	.....	.....
Idemitsu Kosan Co...	Tokuyama	Refinery	30,000 bbls.	$25,000,000	Under Constr.	1957	UOP;J.G.C.	.....	.....
Koa Oil Company....	Iwakuni	Platformer	1,800 bbls.	$1,600,000	Complete	.....	UOP	UOP, Japan Gasoline Co.	Japan Gasoline Co.

* First appearance in tabulation † Added capacity

Construction BOXSCORE Continued on Page 220

To meet the growing demand for Alcoa® Aluminum Electrical Rigid Conduit, all sizes are being stocked in distributors' warehouses for fast shipment anywhere. Fitting manufacturers make a full aluminum line.

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CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Maruzen Oil Co.....	Osaka	Ethyl Ketone Secondary Butyl Alcohol	15 tons 15 tons	$3,000,000	Engineering	.....	.....	Chemical Project Assoc.	Chiyoda
Mitsui Petrochemical Industries	Iwakuni City	Ethylene Oxide, Ethylene Glycol	.....	$30,000,000	Under Constr.	Nov., 1957	Scientific Design	Scientific Design	.....
		Ethylene Unit	.....	.....	Engineering	1957	.....	S&W	S&W
		Phenol Unit	.....	.....	Engineering	1957	Distillers Ltd.	S&W	S&W
		*Cumene Plt.	.....	.....	Under Constr.	1958	Scientific Design	Scientific Design S&W	.....
Mitsubishi Oil Co., Ltd.	Kawasaki	Crude Unit	25,000 bbls.	.....	Complete	.....	.....	Chiyoda	Chiyoda
		Crude Desalter	25,000 bbls.	.....	Complete	.....	.....	Petreco	Chiyoda
		Copper Sweetener	3,500 bbls.	.....	Complete	.....	.....	Union Carbide	Chiyoda
		Platformer	3,000 bbls.	$13,700,000	Under Constr.	1957	UOP	UOP	Chiyoda
		Unifiner	12,500 bbls.	.....	Under Constr.	1957	UOP	UOP	Chiyoda
		Udex	750 bbls.	.....	Under Constr.	1957	UOP	UOP	Chiyoda
Mitsubishi Petrochemical Co.	Yokkaichi	*Ethylene	67.7 tons	$28,000,000	Engineering	1958	S & W	S & W	.....
		*Styrene Monomer	55.4 tons				B.P.M.	B.P.M.	.....
		*Polyethylene	30.8 tons				BASF	BASF	.....
		*Ethylene Oxide	9.2 tons				BASF	BASF	.....
		*Ethylene Glycol	9.2 tons				BASF	BASF	.....
Nihon Gas Kagaku Kogyo	Niigata	Urea	905 tons	.....	.....	1957	.....	Chemico	Chemico
		Ammonia	100 tons	$2,100,000	Engineering	1957	.....	Chemico	Chemico
		Ammonia Sulfate	200 tons	.....	.....	Late 1957	.....	Chemico	Chemico
Nippon Mining Co....	Funagawa	Lube Oil Furfual Unit	.....	.....	.....	.....	Texaco	.....	.....
Nippon Oil Co.....	Niigata	Platformer	1,000 bbls.	$1,890,000	Engineering	1958	UOP	UOP; Japan Gasoline	.....
Nippon Petroleum Refining	Yokahoma	Unifiner-Platformer	3,300 bbls.	$2,500,000	Under Constr.	Dec., 1957	UOP	UOP; Japan Gasoline	.....
		Lube Oil Furfural Unit	700 bbls.	$1,000,000	Engineering	1958	Texaco	Chiyada	.....
Nippon Petrochemical	Kawasaki	Ethylene	25,000 tons/yr.	$16,000,000	Engineering	Spring, 1959	Esso	S&W	.....
		Butadiene	5,000 tons/yr.						
Showa Oil Co.....	Yokkaichi	Refinery	40,000 bbls.	.....	Under Constr.	Dec., 1957	.....	.....	.....
Showa Yuka.....	Japan	Polyethylene	.....	.....	Approved	.....	Phillips	.....	.....
Sunitomo Chemical...	Japan	Ethylene Unit	.....	.....	Engineering	1957	.....	S&W Badger Div.	.....
Toa Nenryo Kogyo...	Shimizu	Ref. Exp. Powerformer; Hydrofiner; Kerosine Acid Treating; Offsite Facilities	32,500 bbls.	$12,500,000	Under Constr.	Late 1958	.....	.....	.....
		Pipestill	25,500 bbls.	.....	.....	Dec., 1957	.....	.....	.....
Korea									
Korean Government..	Chung-ju	Urea Plt.	285 tons	$25,000,000	Under Constr.	1958	Vulcan, Inventa, Texaco, Hydrocarbon	Hydrocarbon, McGraw Vulcan	Hydrocarbon, McGraw
Sumatra									
Standard-Vacuum...	Palembang	Cat. Cracker	11,000 bbls.	$20,000,000	Planning	.....	.....	Foster Wheeler	Foster Wheeler
		Polymerization	1,200 bbls.			.....	.....	Foster Wheeler	Foster Wheeler
		Revamp Existing Plt.	.....			.....	.....	Foster Wheeler	Foster Wheeler
Formosa									
Taiwan Fertilizer, Ltd.	Nankoug	Ammonia Plt to Produce Urea	285 tons	$18,000,000	Under Constr.	1957	Vulcan, Inventa	Hydrocarbon Vulcan	Staff
AUSTRALASIA									
Australia									
Bitumen & Oil Refineries	Sydney	Platformer	2,500 bbls.	.....	Under Constr.	1957	.....	UOP	Local
		Naphtha Unifiner	5,400 bbls.	.....	Under Constr.	1957	.....	UOP	Local
		Diesel Unifiner	2,500 bbls.	.....	Under Constr.	.....	.....	.....	.....
BP Refinery (Kwinana)	Kwinana	Cat. Reformer	10,000 bbls.	.....	Planning	End 1958	.....	UOP, Kellogg	Kellogg
Shell Refining (Australia)	Clyde	Cat. Reformer	6,700 bbls.	.....	Under Constr.	2nd Qtr., 1958	.....	.....	.....
	Geelone	Hydrodesulfuriser	11,000 bbls.	.....	Planned	1st Qtr., 1959	.....	.....	.....
Philippine Islands									
Shell (Philippines)....	Manila	Refinery	.....	.....	Negotiating	.....	.....	.....	.....
Standard-Vacuum....	Manila	Refinery	21,000 bbls.	$35,000,000	Planning	.....	.....	.....	.....

* First appearance in tabulation † Added capacity

NOTE:
Armistead—George Armistead & Co.
Atlantic—Atlantic Ref. Co.
Austin—Austin Co.
Badger Mfg.—Badger Manufacturing Co.
Badger N. V.—Badger-Comprimo N. V.
E. B. Badger Ltd.—E. B. Badger & Sons Ltd.
E. B. Badger Pty.—E. B. Badger & Sons Pty., Ltd.
Barnes—W. M. Barnes Co.
Bechtel—Bechtel Corp.
Beck—Henry C. Beck
Blaw-Knox—Blaw-Knox Co.
Braun—C. F. Braun Co.
Breda—Breda Electromaccania Locomotive
Brown & Root—Brown & Root Construction Co.
Buckner—F. J. Buckner Corp.
Calif. Res.—California Research Corp.
Can. Kellogg—Canadian Kellogg Co.
Cat. Constr.—Catalytic Construction Co.
Chemico—Chemical Construction Co.
Ch. Pro.—Chemical Process, Inc.
C. B. & I.—Chicago Bridge & Iron Co.
Chiyoda—Chiyoda Chemical Engineering & Contruction Co., Ltd.
C. & I.—Chemical & Industrial Corp.
Consd. Eng.—Consolidated Engineering Company
Craig—A. F. Craig & Co.
C.T.I.P.—Compagnia Tecnica Industria Petroli
D & Z—Day & Zimmerman
Delta—Delta Engineering Corp.
Dresser—Cresser Engineering Corp.
Ebasco—Ebasco Services Inc.
E&A—Ehrhart & Associates, Inc.
Esso—Esso Research and Engineering Co.
Edeleanu—Edeleanu Gesellschaft M.B. H.
Etabadger S.A.—Etablissement Badger, S.A.
F&C—Farnsworth & Chambers Co., Inc.
Ferguson—H. K. Ferguson Co.
Fish—The Fish Engineering Corp.
Fluor—Fluor Corp.
Ford, Bacon, Davis—Ford Bacon & Davis Construction Corp.
Foster Wheeler—Foster Wheeler Corp.
Gas Plant Constr.—Gasoline Plant Const. Corp.
Girdler—The Girdler Co.
Girdler (Canada)—Girdler Corp. of Canada, Ltd.
Graff—Graff Engineering & Equipment
Graver—Graver Construction Co.
Grebe & Doremus—Grebe & Doremus Process Co.
Gutte-Hutte—Gutehoffnungshuette
Hedrick—Wyatt C. Hedrick Engineering Corp.
Hercules—Hercules Powder Co.
Hudson—Hudson Engineering Corp.
H&G—Humphreys & Glasgow, Ltd.
H.W.P.—Head Wrightson Process, Ltd.
Hydrocarbon—Hydrocarbon Research, Inc.
Hydro M—Hydrocarbon Mineralael G.m.b.H.
Hydro E—Hydrocarbon Engineering S.A.R.L.
Kaiser—Kaiser Engineers
Kellogg—The M. W. Kellogg Co.
Kellogg P. A.—Kellogg Pan American
KIC—Kellogg International Corp.
Kidde Engrs.—Walter Kidde Engineers Southwest, Inc.
Kidde Constr.—Walter Kidde Constructers, Inc.
Koch—Koch Engineering Company
Koppers—Koppers Co., Inc.
Litwin—Litwin Engineering Co.
Lummus—The Lummus Co.
Lurgi—Lurgi G.m.b.H.
Macco—Macco Corp.
Mannix Gill—Mannix Gill, Ltd.
McGraw—F. H. McGraw & Co.
McKee—Arthur G. McKee Co.
M-C.& S—Merritt-Chapman & Scott Corp.
Olsen—O. L. Olsen
P. A. HydroRes—Pan-American Hydrocarbon Research Co.
Parker—Parker, Steffens & Pearce
Parsons—The Ralph M. Parsons Co.
Petreo—Petroleum Construction Co.
Phillips—Phillips Petroleum Co.
Power Gas—Power Gas Corp., Ltd.
Pritchard—J. F. Pritchard Co.
Procon—Procon, Inc.
Quaker—Quaker Valley Constructers
Russell—Russell Engineering Corp.
Rust—Rust Engr. Co.
SBA—Soc. Badge de L'Azote et des Produits Chimiques du Marly
Scientific Design—Scientific Design Co.
S & S—Singmaster & Breyer Separator-Nobel Co.
Soc. Mob.—Socony-Mobil Oil Co.
Southwestern—Southwestern Constr. Co.
Sohio—Standard Oil Co. of Ohio
Stearns-Roger—Stearns-Roger Mfg. Co.
Sunland—Sunland Refining Co.
S & W—Stone & Webster Engineering Corp. Badger Chemical Division
S & W Canada Ltd.—Stone & Webster Canada Ltd.
Swco—Southwestern Engineering Co.
Tears—Tears Engineers
Tellepsen—Tellepsen Petro-Chem Constructors
Texaco—The Texas Co.
Texas Natural—Texas Natural Gasoline Corp.
Treco—Refinery Engineering Co.
Tuloma—Tuloma Builders
Uhde—The Uhde Corp.
U.O.P.—Universal Oil Products Co.
Vulcan—Vulcan Engineering Div.
J. G. White—J. G. White Eng. Corp.

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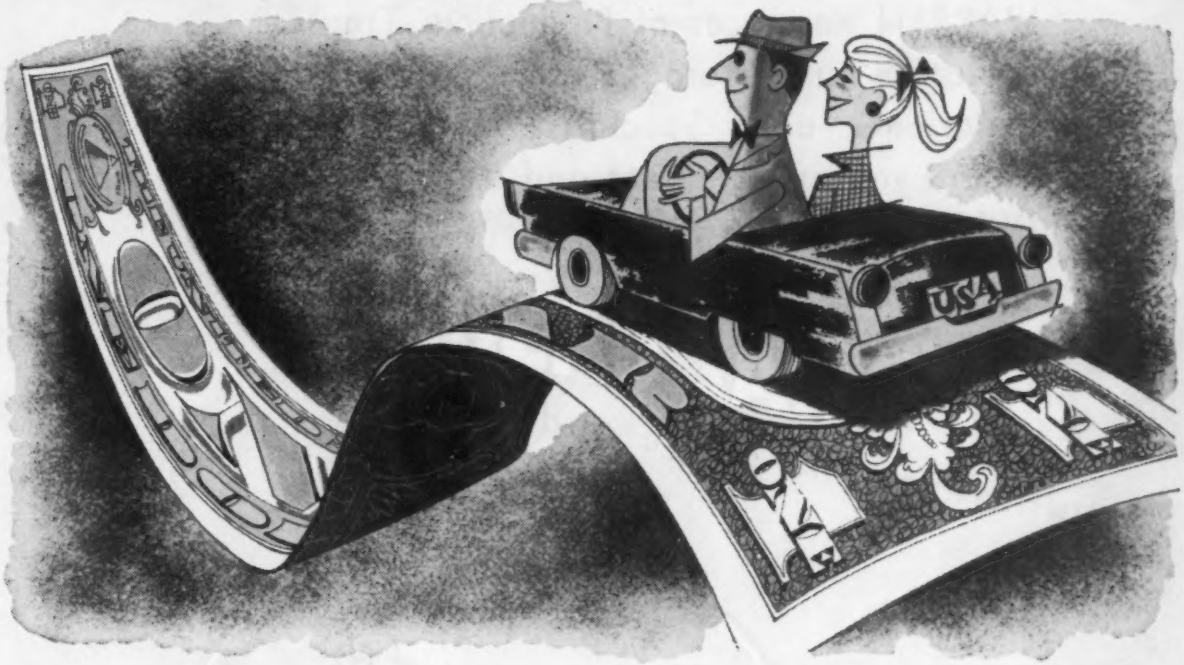
It's surprising how little oil's customers know about the biggest selling petroleum product—gasoline! They never see it or touch it—yet they *use* it every day. All they know is the price they pay . . . and only a few know how big a bargain they really get with today's gasoline.

You'll be helping yourself and your industry by giving oil's customers the *real* story about today's gasoline prices and taxes. Here are the facts:



Today's Gasoline Dollar S-t-r-e-t-c-h-e-s Further

It's a fact that the average American motorist actually gets "more for his money" thanks to the bargain he drives with today's gasoline.

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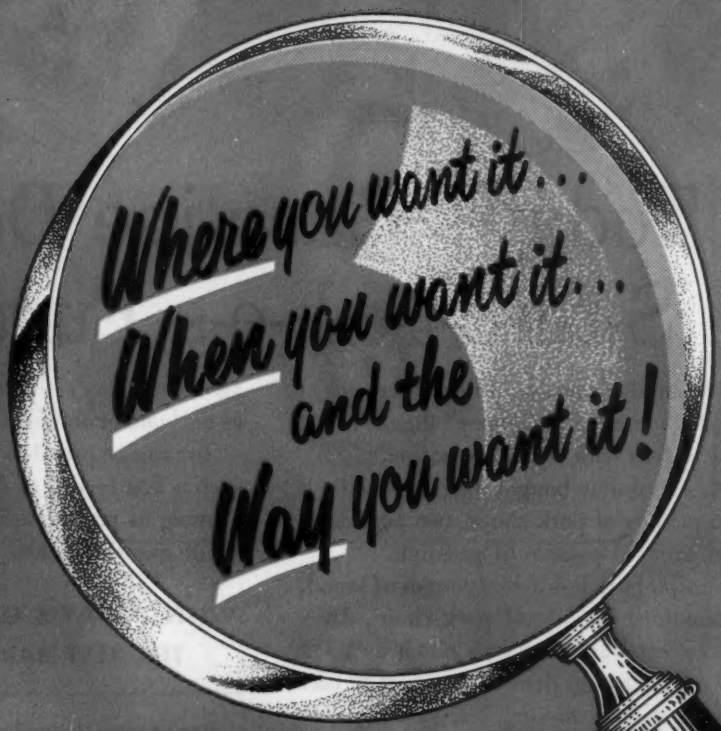

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"Do's and Don't's" for Training Instructors

DO	DON'T	SUGGESTION
Keep trainee informed of his progress, his successes, his mistakes and his opportunities.	Stifle initiative by too close supervision.	When possible, make knowledge of progress: a. Automatic b. Prompt c. Natural to the situation—let trainee find out for himself or tell him constructively.
Teach as fast as practicable and in large amounts so as to give interest and meaning.	Allow habit interference.	Analyze the situation. Push ahead, but watch for danger zones of overlapping habits.
Use a variety of practice materials.	Allow unjustified expense and delay.	Simulate essential situations. Teach general principles. Help trainee develop ability to meet new situations.
Teach general principles.	Assume that trainee will apply them when the time comes.	Assign problems so that he has to work his way out by applying principles.
Provide guidance. Encourage learning by correct doing.	Give too much. Give it too soon. Give it too late.	Guide in early stages and until trainee can make more progress alone. Encourage initiative.

Five Steps to Better Training

Psychological studies have determined that stress of these areas is essential to successful training.

Carl Mullins White
Tulsa

HOW CAN A company know its training program is producing results that justify the dollars spent?

It is difficult to answer this question in many aspects of training. A worker's strengthened loyalty, a supervisor's deepened insight, an executive's stimulated imagination are important but hard to evaluate.

It is sometimes just as difficult to know what training efforts have brought about these desired results—or how.

Even with something as tangible as operating a machine, you might be able to measure increased output after training and still not be able to say definitely what training procedures got the best results—or whether some of the procedures actually interfere with learning.

However, there is one thing certain. Concentration on certain areas of training can improve the entire program. Through objective experiments, psychologists have developed valuable information on some of these areas. By using their findings intelligently you can improve your own training methods along those certain lines.

Following are five areas that psy-

chologists say should receive particular stress in every training program:

- Let the trainee observe his progress.
- Avoid habit interference.
- Use a variety of training materials and aids.
- Teach trainees the principles of their jobs.
- Provide guidance.

Even though these areas apply more forcefully to training in skills, some of the principles could be applied to other courses.

Trainee's Progress. Generally, it is helpful to let the trainee know the success or failure of his efforts. A man's nervous system is in equilibrium when he is succeeding. When failing, he develops tensions and an unpleasant state. These tensions, and satisfaction which he experiences react as punishments and rewards to spur him on. The joy of achievement may give a man a strong sense of satisfaction from doing an otherwise unpleasant task. This is especially true if he not only knows that he is making progress but knows that his boss knows he is making progress.

Instructors can help by:

1. Seeing that the trainee's knowledge of his cuccesses and mistakes is prompt, definite and meaningfully related to the task he wants to learn.

2. Being specific—letting the trainee know the degree and direction of his mistakes, not merely that he is or is not "making satisfactory progress."

Human nature is complex, but it responds to punishments and rewards closely associated to its actions. If a worker opens the wrong valve and causes a severe loss of stock or a flash fire, he will learn fast. The same man will manipulate valves on a synthetic trainer with little progress unless he recognizes his mistakes as they happen.

Here a legitimate question might be raised. If the supervisor or instructor has to be constantly telling trainees about their mistakes, will he be guilty of the "tight supervision" which is known sometimes to interfere with either learning or production? Obviously, he should use discretion to see that his advice is helpful. It is still better if he can arrange the situation so that correction is automatic. He ought to make it easy for trainees to observe their own progress and mistakes.

Habit Interference. Habit interference is the slowing of the learning process caused by confusion in a man's nervous system. This confusion is created by conflicting habits. A simple illustration of habit interference might be that of a small boy whose clothing catches fire. He once saw someone extinguish a fire by jumping in a pool. His Scoutmaster taught him to roll on the ground. His father instructed him to wrap himself in a blanket. All his life he has run for cover when in trouble. All of these response patterns try to assume mastery of him at once so that he may "freeze," unable to do anything.

Psychologists have developed the following principles from their research in habit interference:

a. If the trainee has to learn two or more different responses to approximately the same situation, he will learn slower.

b. If the trainee has to make very similar responses to two very different situations, he will learn slower.

c. When a trainee has one set of habits well learned and is trying to learn a new set of habits, he may run into habit interference.

d. When a trainee is learning two habit patterns at once, he will have serious habit interference at first (usually worse than "c" above).

e. Long training tends to correct habit interference, especially if trainee is informed of his progress. Natural punishment and reward help to eliminate mistakes and encourage learning.

Habit interference is a serious practical problem in the use of synthetic trainers. For instance, when training in the operation of a machinery control panel, the instructor will naturally try to obtain a synthetic trainer which duplicates as nearly as possible the actual working conditions to be encountered on the job. But when the trainee leaves the trainer and begins work, he will likely find some differences. There are three possible ways of meeting this problem:

a. Use several different trainers. This method is excellent but expensive. Clever use of less expensive aids to supplement the trainer may be just as effective.

b. Carefully analyze the differences between the trainer and the real machine and give the trainee corrective instruction.

c. Wait until one set of habits is thoroughly learned before starting to teach a new one. This method, if used to excess, will make training too slow and uninteresting. Trainee may miss the "picture" of the whole task, if it is chopped up into too many small pieces.

The training supervisor must take all factors into consideration and do the best he can in view of his trainees' capacity, the job, his budget and the training materials at hand.

But he must never forget the problem of habit interference. It is a serious one. When a man has been trained to act in a certain way in a given situation and when confronted with a similar set of conditions, he may act in the same way — with serious consequences.

The oil industry has invested heavily in the design of machinery control panels to prevent habit interference. The same rules apply to the design of training equipment.

Variety of Training Aids. Variety in practice material is generally beneficial. But there are instances when it is a hindrance.

Many experiments have been conducted to determine when the instructor should use a very few training materials and under what circumstances he should employ a greater variety. (See Table below).

Effects of Using Different Numbers of Training Aids

A. FEWER

Lower first cost.

Quicker, especially in learning simpler tasks.

Montonous.

Allows wrong habits to go unchallenged and become stronger.

Knowledge limited in application. Trainee may feel lost if confronted with new situations.

May emphasize a non-essential.

B. MORE

Higher first cost.

Slows training. May actually hasten learning of more complicated tasks.

Interesting.

One aid helps to correct mistakes and strengthen good habits learned on another.

Trainee learns general principles and procedures. He can apply his skills in many new situations.

Irons out extraneous matter. Helps

trainee to master the essential knowledge or skill.

It is usually impossible to simulate all the situations that a trainee will later face on his job. The instructor should analyze the situation to see what processes are essential, then:

a. Simulate and teach the essential processes as thoroughly as time and budget will permit.

b. Teach the general principles with the idea of helping the trainee to adjust to new situations.

Knowledge of Principles. Teaching the principles involved in his job usually benefits the learner in three ways:

a. Helps him to learn faster.

b. Helps him to apply his knowledge to new situations.

c. Increases his interest. It helps him to relate the lesson to his own needs. By understanding the overall purpose, he can see how each part of training helps him to do a better job and make progress.

But the instructor must always keep this warning in mind:

Simply learning a general principle does not guarantee that trainees will use it when the time comes. He can improve their capabilities if he will give them practice situations in which they are forced to try to analyze for themselves the similarities and differences between old and new situations.

Guidance. Does it help the trainee to learn a task if he is guided through it several times? The answer is yes.

Research shows that guidance is usually helpful if it is not overdone. The type and amount of guidance, of course, depends on the process you want to teach.

Like every good thing, guidance always reaches a point of diminishing return. If given at the wrong time or too much, it interferes with learning. If the trainee is not ready for it, guidance may confuse and discourage him. If given after he decides that he no longer needs it, the effect may be even more discouraging.

The advantages of proper guidance:

a. Uses the principle of learning by doing.

b. Prevents damages and injuries.

c. Speeds learning.

d. Increases memory.

e. Prevents the learning of bad habits. ##

How to Use Job Evaluation

Job evaluation has proved its worth many times over in refinery operations yet far too few companies are making use of this effective means to:

- **Raise employe efficiency**
- **Determine fair and equitable pay rates for certain jobs**
- **Meet wage demands**

Robley D. Stevens
Management Consultant, Washington, D. C.

DISSATISFACTION OVER pay rates does more to impair employe efficiency, encourage absenteeism, lower morale and increase labor turnover than perhaps any other factor.

There is one sure way to eliminate this morale and efficiency destroyer—set up a sound and practical *job evaluation plan* based on a thorough *analysis* of every job in your organization. Such a program will eliminate the hazards of arbitrary personal opinions and habit in the determination of wage rates by:

- Defining the duties and responsibilities of each job.
- Setting up basic and consistent policies for compensation.

JOB ANALYSIS

What It Is. Job analysis is the process of determining by observation and study, pertinent information relating to the nature of a specific job. It is the determining of the tasks which comprise the job and of the skills, knowledges, abilities, and responsibilities required of the employe for the successful performance of his job. It differentiates one job from all the others.

To be useful for job evaluation, a job analysis should yield a very detailed and specific break-down of all jobs. Such an analysis should provide an organized picture of the abilities which, upon the basis of careful job study, appear to be significant in job competence. Collection of the necessary data in a systematic, orderly way not only reduces effort that might otherwise be dissipated, but it is also helpful in insuring adequate coverage and weighting of all aspects of the job.

What It Comprises. Actually, there are three parts in the analysis of any job:

1. The job must be completely and accurately identified.
2. The tasks of the job must be completely and accurately described.
3. The requirements the job makes upon the worker for successful performance must be indicated.

Job analysis can be used to determine job requirements and the specific qualities required of workers to fill jobs, for recruitment and placement purposes. Workers cannot be trained adequately unless the nature, duties, responsibilities, and like factors of the jobs for which they are being trained are known. By supplying complete information on the nature of all the jobs, it provides the basis for establishing efficient organization plans.

How to Set It Up. The first step in the analysis of jobs is an exact determination of what jobs are and their precise limits, that is, where the jobs begin and where they end.

Jobs in a refinery should be analyzed as they exist, each completed job analysis schedule describing one

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job as currently found in the particular firm being studied.

Contrary to popular belief, your company need not necessarily engage outside counsel to install the system referred to. All that is really essential is reasonable intelligence, objectivity, and a willingness to do the work. This means collecting complete, accurate and intelligible descriptions from the worker himself as well as from his supervisor.

The employe can do his part by filling out a questionnaire supplied by the personnel department. Such participation will help sell the job evaluation plan to the workers, who will feel greater confidence in themselves and in your management by getting a clearer grasp of their functions and duties.

In making a job analysis for job evaluation purposes, the technician should interview inferior as well as superior workers. Both can help to provide a picture of typical job duties and the kinds of information needed to perform the duties adequately. Critical areas of knowledge can also be identified by observing the characteristic differences in job performance among the most competent workers and of the least efficient.

Some companies may find it desirable to maintain a dual filing system, one set of cards for regular use in assembling job analysis information, and one set of cards as a permanent file to facilitate ready location of any particular job analysis item, whether active or inactive, on which information may be needed.

Once the questionnaire is ready for distribution to employes, the decision has to be reached as to which employes in your company will be included in the job analysis-classification plan. Should you include department heads and assistants?

It is usually desirable for a job analysis questionnaire to include pertinent points such as those which follow: Job title, number employed at time of analysis, code number, date on which analysis was made, alternative title, work performed and specific nature, experience, performance requirements, characteristics required of the worker, etc.

Preferably, the points to be covered in the job analysis-classification sheet should be worked out by the personnel department. In fact, it is essential if pitfalls are to be avoided.

Industry is using four types of job evaluation systems:

1. **Point System.** This is the most widely used method and it is rapidly gaining even greater acceptance in American industry.
2. **Ranking System.** With this system it is essential to check and double-check with the various departments to avoid disagreement.
3. **Job Classification.** The success of this method depends on a thorough knowledge of all jobs, so that every work element may be taken into consideration, and the duties and responsibilities of every worker clearly distinguished.
4. **Factor Comparison.** This system has the advantages of simplicity and of establishing a fixed relationship between job value and actual compensation.

JOB EVALUATION

What It Is. Assuming that your management has adopted the procedures and methodology to be employed in the job analysis plan, the next step is to decide how good your present method of determining relative base

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Remarkable resistance to heat and harsh chemicals

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Highly resistant to strong acids and bases at all temperatures.

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Maximum efficiency under temperatures from -100° F. to 550° F.

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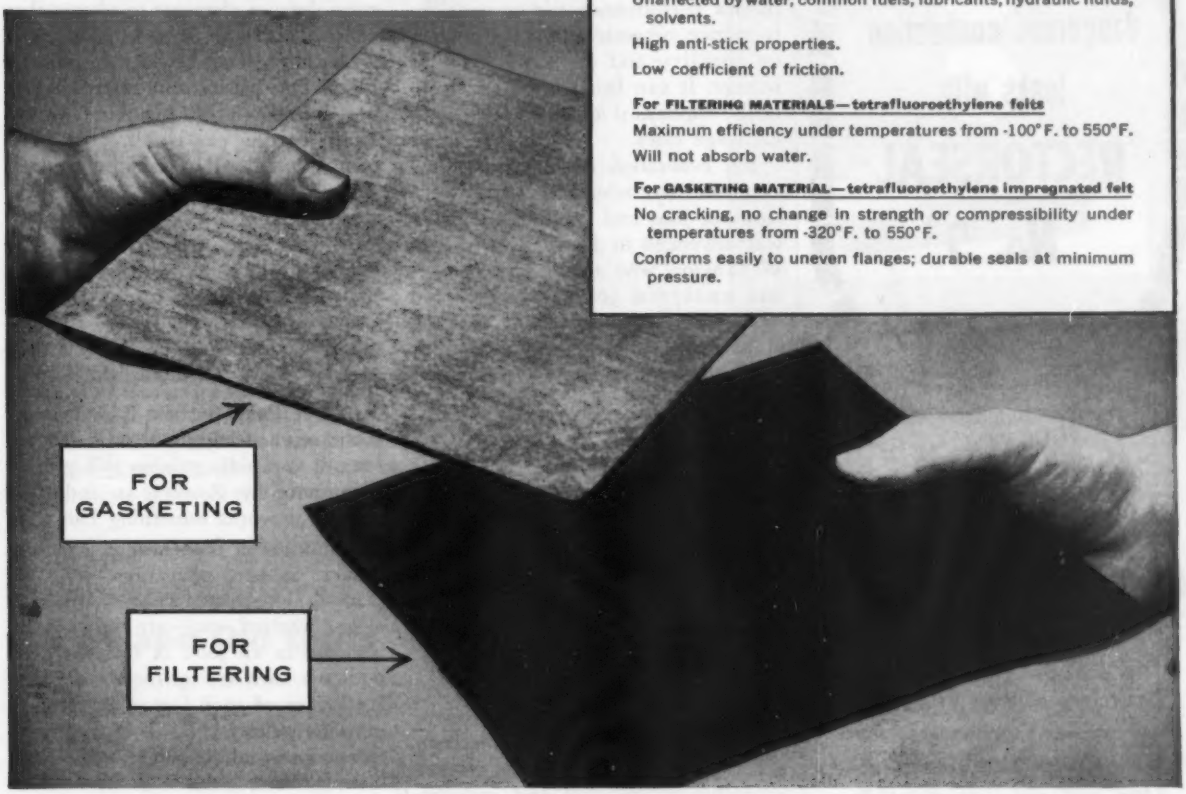
No cracking, no change in strength or compressibility under temperatures from -320° F. to 550° F.

Conforms easily to uneven flanges; durable seals at minimum pressure.



New ARMALON® felts show exceptional service life in strong corrosives, temperatures up to 550° F.

Corrosion-resistant filters and gaskets of new "Armalon"* tetrafluoroethylene resin assure extraordinary long life felts where other materials fail entirely. They've proved their superiority in systems handling strong acids and bases—at temperatures from -320°F. to 550°F.

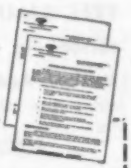
"Armalon" is the new felted form of Du Pont's "Teflon"** tetrafluoroethylene resin, available in two constructions—one for filtering, the other impregnated for gasketing†. "Armalon" is inert to water, common fuels, lubricants, hydraulic fluids, solvents and corrosive chemicals.

FILTERS of "Armalon" remove fine particles at high flow rates with minimum pressure drop. Anti-stick property of "Armalon" means longer service life, easier cleaning.

GASKETS of "Armalon" seal securely and last months, even years, longer than other materials. Advantages include substantial reductions in costly replacement shutdowns.

For more facts that may help you find a place for "Armalon" felts in your operations, fill out and mail the coupon. You'll receive Du Pont's free descriptive bulletin, including specifications.

*"Armalon" is Du Pont's registered trademark for its tetrafluoroethylene felts and impregnated felts.
**"Teflon" is Du Pont's registered trademark for its tetrafluoroethylene fiber.
†"Armalon" tetrafluoroethylene impregnated felt is covered by U. S. Patent 2,764,506.



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Rectorseal No. 5 is slow drying —soft setting—non-hardening. Withstands pressures to 11,350 psi., temperatures to 350° F.

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money rates are and then to install one of the four basic job evaluation systems now in use.

Actually, job evaluation provides a working tool to appraise the employe's performance and provide information necessary to gain the highest quality and efficiency of every worker. It can bring some order out of the haphazard assigning of prevailing wage rates.

Job evaluation is not new. However, the first scientific plan for the study of jobs and wage relationships was advanced in 1881, by Frederick W. Taylor, who made time studies and analyzed jobs into units and duties. The analysis consisted largely of a listing of the steps needed for production and the time necessary for each step, so as to accumulate a standard time for the production or work performance of a single unit. Out of this practical approach arose the many incentive wage payment plans which we find in evidence today.

Employers generally favor the use and installation of job evaluation because they are assured of a relatively stable unit labor cost and greater employe efficiency. It is unfair to pay the same wage to a slow worker as to a more efficient one, and a system which rewards the individual worker according to his skill and industry based upon scientific study is therefore both more equitable and more desirable.

What It Comprises. There are four types of job evaluation systems:

1. **The Ranking System.** This is sometimes referred to as the card-sorting system, because the jobs are arranged from high to low, as in the cards of a playing-card deck. All the jobs are ranked in order of importance—that is, in terms of other jobs, not in terms of money, and without reference to the person holding down the job. The best method is to list the jobs in each department on a separate sheet, horizontally, and have the department heads arrange them vertically, in order of importance. The individual department lists are then combined into one organizational chart. With this type of ranking, it is essential to check and double-check with the various departments to avoid disagreement.

2. **Job Classification System.** Under this system, a number of categories or grades are established in advance, and the jobs are assigned to these classifications. Such a method presupposes that every job in your company contains definite elements or phases that can be classified into grades. The grades are then established on the basis of difficulty and responsibility, as represented by the number and kinds of rules regulating the work being done, and by whether or not, and how often the work is subject to check. The success of such a job-measuring stick depends on a thorough knowledge of all the jobs, so that every work element may be taken into consideration, and the duties and responsibilities of every worker clearly distinguished.

3. **The Point System.** This method is the most widely used today. Moreover, it is rapidly gaining still greater acceptance by American industry. Briefly, it works something like this:

A number of predetermined factors —such as age, education, years of training, experience needed, physical effort involved, etc.—are found to be common in all jobs. A schedule of points is then set up for the various gradations of each factor. Each level must be strictly defined, so that consistent interpretations of the elements included in each factor may be made. The levels or grades in each factor should be expressed or defined in written form, and it is also desirable to have each definition accompanied by examples of standard or well-defined jobs that have taken into consideration the following:

- The minimum ability which an employe brings to the job.
- Extent to which he is called upon to use his abilities.
- Responsibilities which the employer demands on the job.
- Conditions under which the job must be performed.

When the individual jobs have been evaluated the sum of the job factors should be well under the maximum total points of the system.

4. **Factor Comparison System.** There are several differences between this method and the point system. One is that the graded factors are assumed to be fundamental to all jobs. Another is that jobs are evaluated

For more data on advertised products, use Readers' Service Cards, last page.

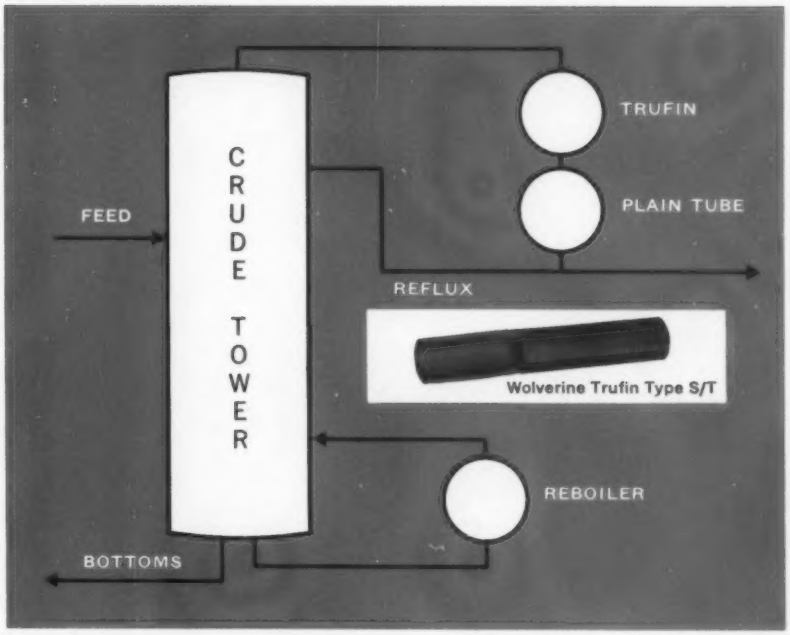
Where Trufin is Most Effective

The use of Wolverine Trufin is most effective in heat transfer applications where outside heat transfer coefficients are low when compared with inside coefficient values — such as those described below.

AIR HEATING OR COOLING where the air is outside the tube and circulating water or condensing steam is inside.

REFRIGERANT AND OTHER HYDROCARBON CONDENSING where the refrigerant is outside and circulating water inside.

OIL COOLING OR HEATING where the oil is outside and steam or water inside. In all such cases the added outside heat transfer surface gained through the use of integrally finned Wolverine Trufin can reduce the size and cost of the heat exchanger and yield real savings.



Can use Trufin in New and Old Units

With the passing of each day Wolverine Trufin Type S/T is finding ever increasing acceptance in the chemical, petro-chemical and petroleum-refining fields . . . for use in retubing existing equipment and in the design of new units.

Retubing an existing heat exchanger can be accomplished, in many instances, simply by directly substituting Trufin Type S/T for plain tube. Because its integral fins give it greater outside surface area Trufin packs more heat transfer surface into a given space —steps up the capacity of existing units.

When designing new equipment Trufin Type S/T permits the design of smaller, more efficient units with a direct saving in materials, time and labor. Trufin Type S/T is widely used in gasoline condensing, butylene condensing and lube oil cooling—is particularly effective in handling light hydrocarbons.

NEW BOOK—FREE

Actual cost breakdowns showing the cost of Wolverine Trufin in actual comparison to prime surface tube are available in Wolverine's brand new book—"Comparative Heat Exchanger Costs". Write for your copy.

Crude Unit:

HEAT DUTY AND ON STREAM TIME BOTH UP WHEN TRUFIN S/T USED

By Ernest Dodd

Met an engineer the other day who accused us of being prejudiced about Wolverine Trufin® Type S/T—the integrally finned condenser tube. Actually we had no defense—how could we feel any other way about a product that performs like Trufin.

Consider, for example, the experience of engineers in a large Eastern refinery when they used Trufin Type S/T in one of two overhead condensers on their crude tower. This unit was placed on stream in March, 1956 and 14 months later was shut down for turn-around.

The application consisted of two units in series—the top one tubed with Wolverine Trufin Type S/T and the lower one with prime surface condenser tube. Upon inspection of the two bundles it was discovered that although the finned tube unit was fouled on the shell side due to the relatively sour crude, the fouling followed the exact contour of the fins. No fins were occluded and the bundle appeared in extremely good condition. This fouling matter was extremely soft and could be cleaned simply by turning a hose on it and washing it out.

However, actual comparison proved that the lower bundle—which was tubed with plain tube—was in very poor shape. The shell side fouling was an extremely tough scale formation which required scraping in order to clean it up. The tube side of this bundle was in approximately the same condition as the finned tube unit.

During the 14 months of operation the engineers at this refinery estimated that they realized a minimum increase in heat duty of 40%. It was also the first time that their crude tower had been operated for a full year—without shutting down to clean the condensers.

Where Wolverine Trufin Type S/T is concerned you just bet that we're prejudiced—and we're proud of it, too. Next time you have a unit off stream for retubing why not look into the economies of Trufin Type S/T . . . and prove for yourself how this integrally finned condenser tube can boost performance while saving you time and money.

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"A" Tubed with 325 pieces of ¾ inch x .065 inch prime surface tube.

"B" Tubed with 190 pieces of Wolverine Trufin Type S/T—#195065

Take a look at the sketches of the two shell and tube condensers shown on this page. One is substantially larger than the other—**but both handle the same heat load.**

That's important because it represents vital savings in metal—both in the size of the condenser shell and in the number of tubes required. It also means additional savings in heat exchanger maintenance—**because there are 135 fewer tubes to clean or replace.**

Assuming that Condenser "A" is a four-pass unit and Condenser "B" a two-pass unit, it is interesting to note that "B" (tubed with Trufin Type S/T) **has the least tube side pressure drop.**

With all factors such as alloys, water conditions, temperatures and unit design taken into consideration the use of Trufin Type S/T—with an increase in tube side velocity—can give a greater boost in heat transfer capacities. **This provides the equivalent of additional equipment without additional cost—adds up to more BTU's per $$$.**

Next time you are considering condenser tube—for new equipment or old—remember Wolverine Trufin and the savings it makes possible. For more complete information write for your copy of the Wolverine Trufin Catalog.

This is Wolverine Trufin Type S/T

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relatively, using certain existing jobs as points or degrees on the evaluation scale, rather than descriptive definitions.

This system has the advantages of simplicity and of establishing a fixed relationship between job value and actual compensation, since it is based on key jobs for which compensation is standard or, at any rate, not subject to controversy.

Once the key jobs have been selected, they are ranked from highest to lowest in order of importance. After the ranking, however, the key jobs are evaluated by study and examination of individual job descriptions. All other jobs are then related to the key jobs, and the final result is an agreed-upon, company-wide grading system.

The important thing to remember in any job evaluation plan is that it must not become mechanical, but should be checked periodically to determine how effectively it is being administered. This is especially true in the oil industry, where competition among firms for skilled workers is high, and where tradition and precedent are of the utmost importance in raising employe efficiency, solving wage demands and good industrial relations ##

About the Author

ROBLEY D. STEVENS is a Washington correspondent and management consultant specializing in public-labor-personnel relations. He is a former representative of the Labor department and was connected with the Army and Navy departments in civilian capacities. He has written two books on labor relations as well as a number of magazine articles in that field. Stevens holds both LL.B. and LL.D. degrees from Blackstone School of Law.

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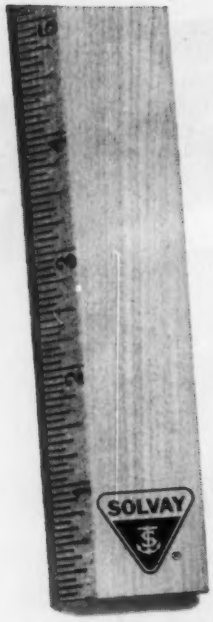

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If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

"If Oil Could Speak" it would tell the American public:

Is Oil Research Comparable with Other Industries?

Expenditures on research for a new manufactured product seldom exceed five percent of gross income, whereas expenditures for petroleum exploration and dry holes require about 30 percent of the gross income of the industry, exclusive of development expenditures which represent an additional 35 percent of oil's gross income. This also is research. Furthermore, much research leads to improvements in existing processes and equipment which will pay for the cost of the work, whereas the search for oil must discover new deposits comparable with new inventions in order to result in any source of income.

Is Oil a Good Investment?

Out of the 27 industries that have stock listed on the New York Stock Exchange, petroleum ranks second in the line-up of securities which pay the highest dividends to investors.

Has Gasoline Efficiency Increased?

Gasoline efficiency has increased 77 percent since 1926, yet today's gasoline costs only about a penny more per gallon than it did 30 years ago (sans taxes).

Have Oil Prices Kept Pace With Cost?

No. While crude oil prices have increased only nominally in the past decade, exploration, development and production costs have more than doubled.

What Lies Ahead in Petroleum Demand?

Since 1946, the combined use of oil and gas in the U. S. has approximately doubled. Since population has increased less than 20 percent, this means a rise in per capita consumption of oil by more than 60 percent within 10 years. The use of oil will continue to increase rapidly and is expected to double within 15 to 20 years.

How Many Miles of Pipe Line are in the U. S.?

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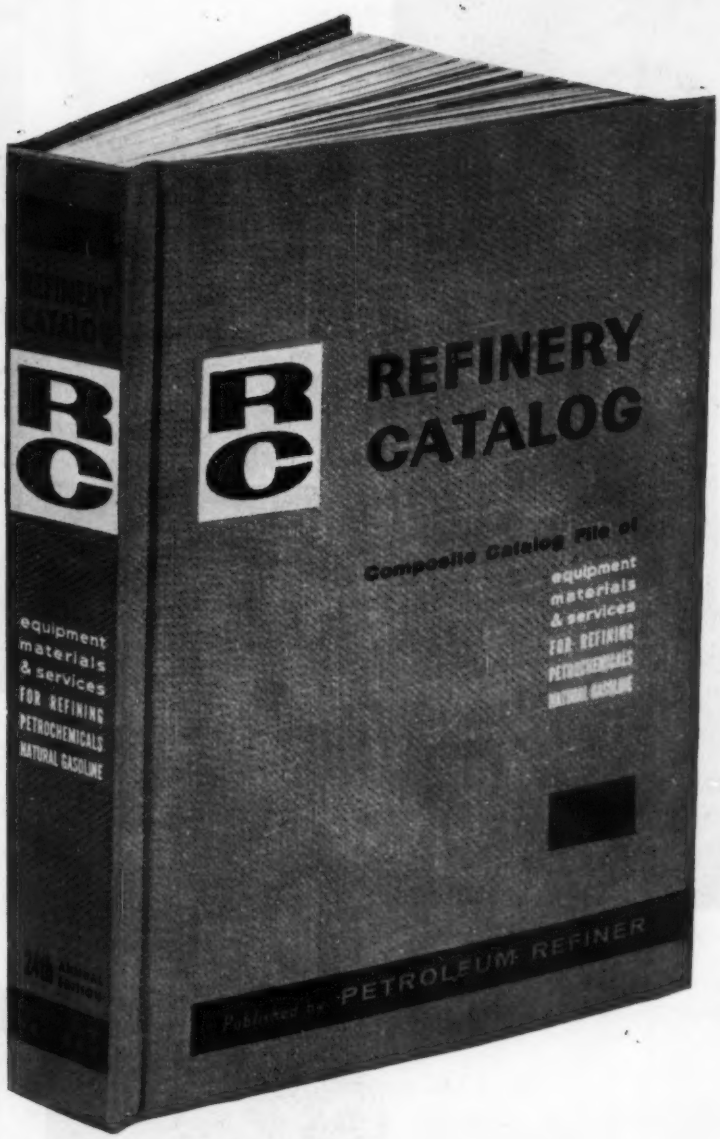

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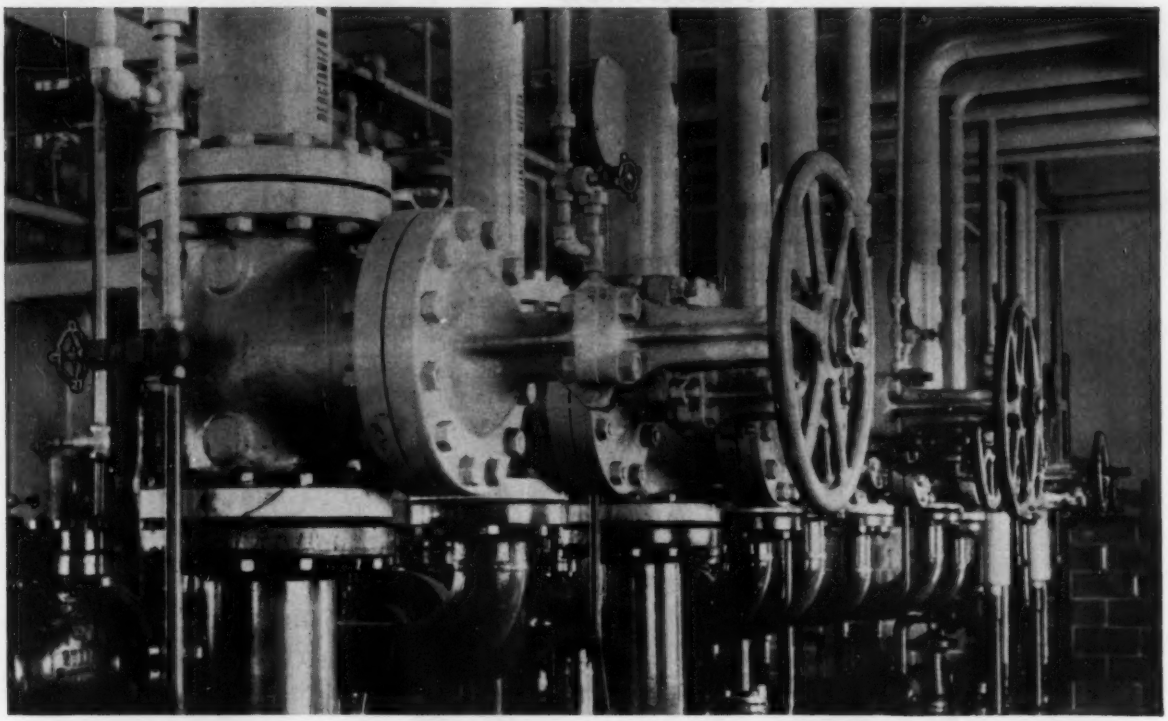

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Safety and Fire Protection Part 10

The white elephant being studied by the author (right) and a Socony-Mobil official is the key figure in a novel refinery safety promotion idea. At first, "Whitie" is made the unwelcome property of the department head whose operation has the poorest accident record during a given month. If no department has an accident during the month he is placed on the refinery manager's desk. When no accidents occur in a refinery for a year he is put to rest on the manufacturing director's desk. If a plant has no accidents for two years "Whitie" is shunted off to the elephants' graveyard.

How to Organize a Safety Program

Behind every successful safety program are four essential ingredients: (1) Top management planning, (2) Enthusiastic executive participation, (3) Specific functions for safety leaders, and (4) Proper attitude on the part of all concerned.

J. L. Risinger
Safety and Fire Protection Consultant, Maplewood, New Jersey

ORGANIZATION OF refinery fire protection programs are closely integrated with accident prevention for the following reasons:

1. Failure in fire prevention or fire control often results in explosion or fire that results in injury or death to people as well as damage to property.

2. Human failure is the chief cause of accidents and fires. In many cases the same type of human error is most conducive to the cause of either or both injury and fire. The prevalence of this factor in the oil industry has brought accident and fire prevention into a common ground.

3. The fire fighting phase of fire protection is allied to the fire protection engineering phase of prevention and control.

Whether the safety department is designated as carrying fire protection makes no difference—it cannot escape the responsibility of providing a service that will tend to reduce the frequency of serious injury to employes from failure to prevent fires and explosions. The prevailing policy among oil companies is to integrate all phases of fire protection with safety.

Safety Starts at the Top. In the fitting or adjusting of a safety program into the scope of organization, purposes and objectives of a company, it is fundamentally imperative that:

1. Company executives recognize the importance and vital necessity of a definite and effective organization of the safety department; that its objectives are well defined and its channels of procedure are kept open.

2. The safety supervisor is influential enough for his ideas to merit the consideration of senior executives in their planning; that he be tactful enough to cause the correction of hazards specifically and the adherence to standards of safe practices in generai, without friction; that he be thorough enough to be correct in detail and not lose his sense of proportion to the extent of over emphasizing non-essentials.

3. The safety organization must function effectively with service departments, planning agencies and operating departments, so that safety links its way into and through every activity of the company from the chief executive on down.

Studies reveal that the best results are obtained when

accident and fire prevention are organized in a manner to place definite responsibility on specialists without relieving supervisors of their responsibilities for carrying it as a part of every operation, procedure and activity.

"Authority" vs. "Leeway." It is to be kept in mind that the safety department is a planning and coordinating agency, designed to cause the carrying of the safety ideas into every fabric of the organization. Many safety men cannot or do not get the difference between authority and leeway.

As authority is increased, responsibilities are increased. As the safety man's responsibilities are increased, it is the tendency of line supervision to get out from under, and thumb the entire job over to the safety man. Even worse, there is a tendency among some safety men to accept the responsibility, rather than push it back where it belongs.

When management and supervision reach the stage where they recognize these inequities in safety responsibility—and do something about them—a downward trend in accident rates will be in the offing.

Regardless of the placement of the safety department in an organization, to be effective the leader must be given leeway to maintain an identity and to work freely with those who are to accept plans, carry the plans into execution, plan their own work and, in short, put accident and fire prevention into successful operation.

The Safety Team. This simply means the organization of personnel, skills and facilities toward a common objective as a responsibility of each person involved. To properly reach this objective, the safety specialist should sparkplug the enlistment of all members of management,

HOW ONE COMPANY ORGANIZED A SUCCESSFUL SAFETY PROGRAM

(The following outline guided the Socony-Mobile Oil Company in setting up safety programs for its domestic and international operations.)

Planning Starts at the Top

After careful study by the board of directors, managers of the departments and special members of their staffs are called together for the purpose of establishing a well defined safety and fire protection organization and program. The following items are of first consideration:

1. The institution of reports and records.
2. Definition of duties of the coordinating office (safety department).
3. Definition and promulgation of safety and fire protection policy and channels of responsibility. These should be publicized by the president or general manager of the company.
4. Institution of recognition and incentive plans.
5. Safety, fire protection and first aid training.
6. Definition of plans for participation by all members of management.
7. Correct organization of the safety department to be of greatest assistance to management.
8. Placement of the safety organization at a level indicative of the importance of the program.
9. Organization of a safety team that will obtain the greatest benefit from the skills and facilities available.
10. Establishment of an approach that will emphasize assistance, rather than policing.
11. Organization of management and workmen advisory committees.
12. Organization of fire protection engineering groups and committees.

The management group will reconvene from time to time to receive reports of progress from department managers, and give consideration to other phases of the program.

Establish Functions of the Safety Supervisor

The status of a central safety man of a company or division is no longer that of an inspector and/or doer of safety and fire protection. He is an assistant and advisor to the manager and supervisor of the respective departments, coordinator of the program in the various departments, the provider of information on progress of the entire program and the general promoter of the program. This work is done under the guidance of the manager or director to whom he reports. When working in a department, he is working for and under the approval of the manager of the respective department, the responsibility for which is that of each department manager.

The assistance which this man can give, and the soundness of his advice will depend upon his background, training, experience, ability to plan, coordination and cooperative ability in serving managers, and ability and willingness to make the balls for managements to throw.

Many good safety and fire protection programs have failed because safety men took the responsibility off the managers, superintendents and supervisors.

Outline Extent of Executive Participation

The most effective safety and fire protection programs have been those sponsored by top executives, who let it be known by word and action that they consider the safety of employes of first importance. Following are suggestions for executives:

1. Top executives and managers can add greatly to the acceptance of the program if they will make it a point to include safety in all meetings and by mentioning it in all talks to groups.
2. Letters of congratulations and/or presentation of awards by top executives to employes with outstanding safety records are effective promotional measures.
3. The safety and fire protection program of the entire company is the program of the president and general manager, and should be one of which they are proud. The program of each department is likewise that of the manager of the department.

Put the Program Into Action

1. After the original safety and fire protection meeting, each manager should institute the program in his department and place upon each supervisor the responsibility for safety and fire protection commensurate with the scope of the job of each.
2. Using the forms provided by the central records department, the manager should proceed to institute a reporting system and records for his department, i.e., current injury, accident and fire reports; monthly disabling injury reports; monthly motor vehicle accident reports.

All reports should be cleared through the department manager's office and sent by him to the central safety and fire protection coordinating office for compilation into reports for the entire company. He should keep the president and general manager informed on the occurrence of major accidents and fires in his department.

3. The manager of the department should set up committees at his plants and/or other operations to enlist individual participation in the program.
4. He should institute safety and fire protection inspections by himself when in the field, by his engineers and other members of his staff as suited to his operations. The safety man of the company should participate in these inspections when requested to do so by the manager of the department. If reports of the inspection are made they should be sent to the manager of the department.
5. The department manager should plan and institute a training program in safety and fire protection for his staff and supervisors, and provide such aid as is necessary to supervisors in carrying this training to employes in the plants. The central safety man should assist in this training if desired by the manager of the department, and in a manner as indicated by the manager of the department.
6. When records are instituted, the manager should enter his operations in safety contests.
7. The department manager and his staff should work with other departments to establish a study of fire extinguishing equipment for the purpose of providing the most suited and effective extinguishers at the lowest possible cost.

both line and staff, into an acceptance of responsibility all along the line.

Under this policy, the president is responsible for the success of safety and fire protection in the company. The director is responsible for his department, the manager for his plant, the foreman for his group and the gang leader for those under his supervision.

Service department heads, engineers, industrial and public relations personnel are responsible for safety in their work and to exemplify it in contacts commensurate with the company's policy.

Use the Right Approach. Not too many years ago a few safety men and members of top management reached the conclusion that the past approach was wrong, that safety and fire protection was not purely mechanical but chiefly a human control factor. They agreed that both the human and the mechanical aspects of safety were a responsibility of management, both at the head office and in the field, and that the service department or staff was not only responsible to establish safety in its own department, but to make safety a part of each service rendered.

They further agreed that the safety man's job should not be purely that of an inspector, but instead he should organize the team, sparkplug the program, and assist management from the president to the supervisor in carrying out each respective safety and fire protection program.

Attitude of Executive Management. Attitude of executives and managers is the only guide to the importance a company places on any function. It has been found that more of it is required in the success of safety and fire protection than in any other phase of the company's business.

When the president and other executives include safety in their speeches and individual contact, personally reward individuals with outstanding safety records then the company will be setting into motion the type of attitude that will do more toward reducing accidents and fires than can be done by many safety men crying in the wilderness.

It is truly said that good public relations is simply putting your house in order and inviting the public to look at it. Likewise, it is not only necessary for members of management to have quality and quantity of correct attitude toward safety, but they must effectively reveal it if results are to be obtained.

By quality of correct attitude, we mean that which motivates the executive to place safety and fire protection at an effective level in his organization and to lead it in a manner to obtain the desired results. By quantity of correct attitude, we mean enough of it to reveal to every supervisor and workman that the executive wants the safety job done and believes it can be done to such an extent that he expects it to be done.

Attitude of Safety and Fire Protection Heads. This factor may not have been given before as a means of obtaining and maintaining a successful safety program. However, there have been many instances where the proper attitude and philosophy of the safety man saved the day. On the otherhand, the incorrect attitude of the safety man will invariably wreck the results of any well planned safety program.

It is sometimes difficult to determine which is more valuable in a safety director—engineering ability, ability to deal with people, college training in safety engineering or experience in the school of hard knocks. Not one of these is of any value unless at least one of the others is developed. And all fall short unless the safety supervisor has, or has caused to develop, that trait which causes those with whom he deals to enjoy his associations and want to do the job of safety not as he demands, but as he helps and leads them to do it. This trait may be defined as a combination of both attitude and technique of approach.

The supervisor is still somewhat prone to assume the attitude of, "Oh that's the safety man's job." In their anxiety to do a good job, some safety supervisors have been prone to accept this attitude and before long find themselves attempting to do all the safety work instead of organizing and leading the safety team. The correct attitude of causing safety to be done, rather than a high powered attitude on the part of the safety man begets correct attitudes on the part of others concerned.

Provision of Reports and Records. Accident statistics are developed to prevent accidents. They do this in several ways i.e., they measure the need for greater safety effort, evaluate the effectiveness of safety work and can be used to reveal and credit outstanding safety accomplishments. Some promotional ideas include:

1. A simple board at the entrance to the property or in the ship, stating, "This plant has worked (blank) days without a disabling injury," will serve as a constant stimulus if changed each day.

2. Based on available statistics, the standing of each section or plant of a refinery or other operation can be published in a manner to stimulate competition.

3. Establish a certificate of merit plan. The incentive provided from an award program will do much to improve employe attitude and interest, particularly if presentations are made by the president or other top company official. The certificates can be awarded on any level—plants, divisions, departments, foremen's groups or groups of vehicle drivers.

4. Posters are effective if used properly. A poor system of change of posters, unattractive boards or poor selection of posters may detract from a safety program.

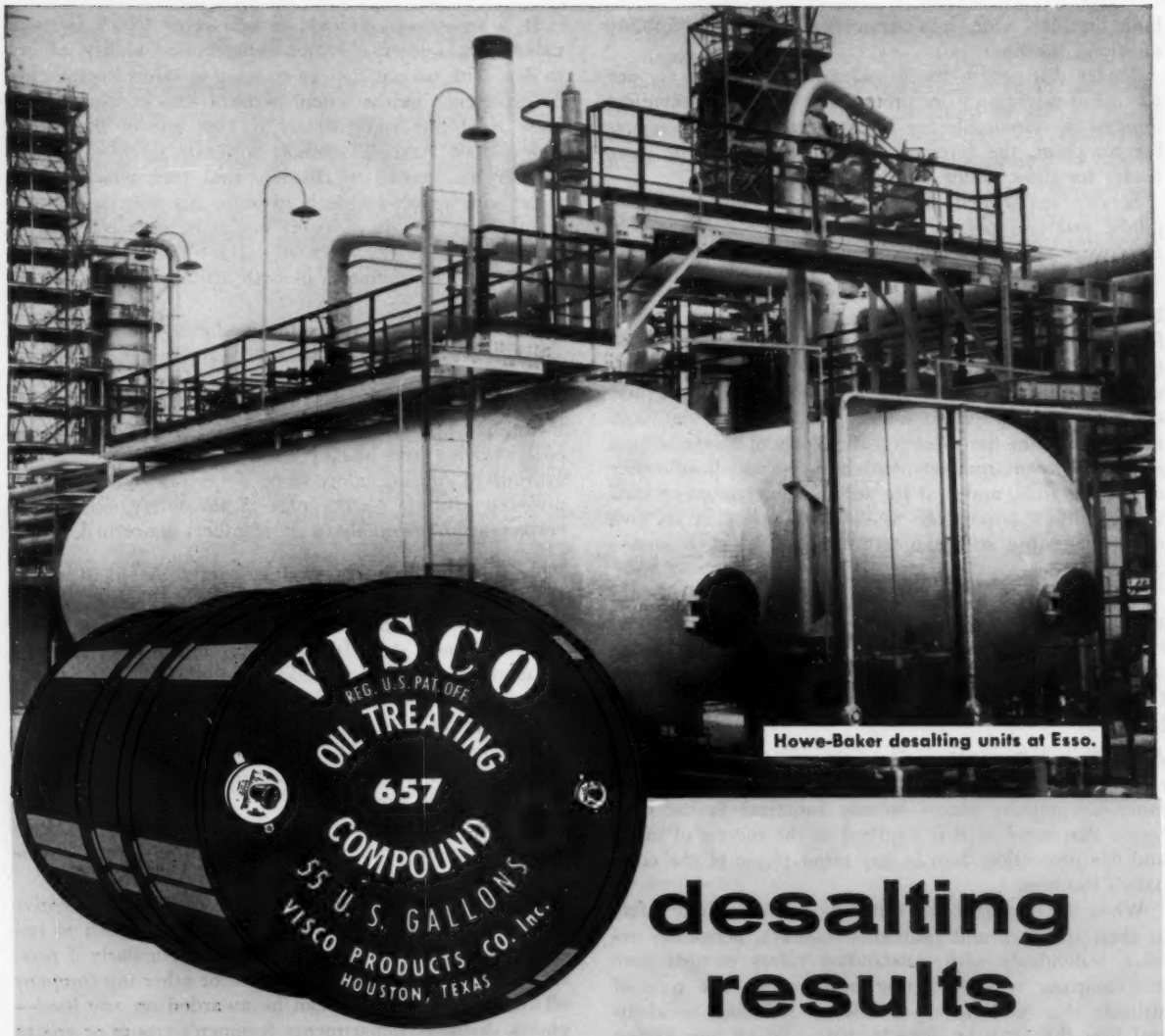
5. **The "White Elephant" plan.** (See Figure 1). This idea has been used with great success at many locations. A white toy elephant is placed on the desk of the department head whose operations had the poorest accident record during the preceding month.

When no department has an accident during the month "Whitie" goes to the refinery manager's desk. When no accidents occur for a year in the entire plant he is put to rest on the manufacturing director's desk.

One 500-employe plant placed the elephant on the director's desk the second year after the plan was started. However, he didn't stay there. During the first year of his stay on the director's desk the plant had a disabling injury. So, "Whitie" went back to the plant.

If no disabling injuries had occurred for two years in succession, the elephant would have been retired and kept out permanently.

Part 11 will appear in an early issue of PETROLEUM REFINER



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What's Happening . . .

. . . in the Industry

Why Amoco Closed Brownsville Plant

Process was technically O. K. but too expensive. Here's the story behind the shutdown.

Technically, the feasibility of the hydrocarbon synthesis process has been demonstrated in the Brownsville plant of Amoco Chemicals Corp. Economically, however, the process cannot produce gasoline and chemicals from natural gas as cheaply as they can be made by other processes. Accordingly, shutdown of the plant was announced.

All sections of Amoco's Brownsville plant have been in operation for one year or more. As sections were placed in operation, technical problems were encountered in the oxygen section, the gas generation section, the catalyst preparation section, and the synthesis reaction section. Most problems were solved in short time by a combination of process and mechanical revisions.

Despite improved performance of the synthesis reaction section, the most difficult problems were encountered in that section. Major problems included:

1. Mechanical failure and unsatisfactory operation of the filters used to separate entrained catalyst from the reactor effluent gases.

2. Failure to obtain the highly efficient gas-solids contacting desired in the reactors.

These problems required technical study and plant-scale testing. The first problem was solved. The second appears to have been solved as indicated by tests in a plant reactor of intermediate size. The results of that work were being translated to the large reactors when the plant was shutdown.

Looking Back. The Brownsville hydrocarbon synthesis plant was constructed and operated by Carthage Hydrocol, Inc., until its shutdown in June, 1953.

In December, 1953, Pan American Petroleum Corp., an affiliate of Standard Oil Company (Indiana), acquired an option on the stock of Carthage Hydrocol, Inc. The plant finally became a part of Amoco Chemicals Corp. in January, 1957.

Pan American's interest in the plant was dictated by two primary considerations:

1. Pan American owned an adjoining chemical plant for processing water-soluble chemicals produced by Carthage.

2. Pan American had an extensive background in research and development of the basic synthesis process which, it appeared, could be successfully applied to the Brownsville plant.

Estimates were made for necessary plant modifications and additions, and an assured supply of natural gas was obtained. Estimates of anticipated performance were also completed, resulting in the conclusion that the plant should be acquired by Pan American. In March, 1954, the option was exercised, and Pan American embarked upon a two-phase program as follows:

Phase 1—Completion of modifications and additions as required to permit demonstration of operability of the process. It was anticipated that operations would not be profitable during Phase 1.

Phase 2—If operability was demonstrated, expansion of the plant to result in a satisfactory financial return.

The Phase 1 engineering and construction period began immediately with The Lummus Company retained as contractors.

Discussion. The two basic types of revisions, made prior to Phase 1 operations, include:

1. Process changes necessary to to make the process operate satisfactorily.

2. Revamp of all equipment plus installing new equipment to give the minimum required operating flexibility.

The major modifications made and the results from plant operations are discussed below for each plant section.

Oxygen Production

The oxygen plant was modified as follows:

1. Repair of insulation. The oxygen plants operate as low as—300 F. High heat leaks by Carthage had

GENERAL PROCESS DESCRIPTION

The hydrocarbon synthesis process is based on the reaction of carbon monoxide and hydrogen in the presence of powdered iron catalyst to produce a variety of hydrocarbons and oxygenated chemicals. Raw materials for the process are oxygen and natural gas (essentially methane). Oxygen is obtained by fractional distillation of liquid air at very low temperatures (about —300 F). Natural gas, which the plant was expected to consume in quantities up to about 100 million cubic feet per day, is obtained from nearby gas fields.

Synthesis gas (a mixture of carbon monoxide and hydrogen), is produced by partial oxidation of the natural gas with oxygen of 95 percent purity. This "controlled partial combustion" step is performed without the use of a catalyst at a pressure of about 300 psi, and at temperatures in the range of about 2500-3500 F.

The iron catalyst used in the synthesis reaction step is derived from mill scale (obtained from steel mill rolling operations). The mill scale is properly ground, sized, and impregnated with a chemical promoter. The resulting material is reacted with hydrogen under suitable conditions, producing powdered iron of relatively high purity. The final step in preparation of the catalyst is treatment with synthesis gas under carefully controlled conditions. This is termed "activation."

The synthesis reaction step, wherein the carbon monoxide and hydrogen are reacted in the presence of the catalyst, is conducted at a pressure of about 400 psi at a tempertaure of approximately 600 F. The catalyst is maintained in a "fluidized" state, by upward passage of gases through the reactor. The heat of reaction must be removed to maintain the desired temperature.

Crude mixed products of the synthesis reaction—light gases, hydrocarbon liquids, and crude chemicals dissolved in water—are sent to their respective processing areas. The light olefins are treated in a conventional catalytic polymerization unit to produce gasoline products. The synthetic oil stream is refined in a fluid catalytic cracking unit to obtain high ultimate recovery of gasoline .

The water-soluble chemicals are separated and purified in an adjoining plant originally built by Pan American and operated by that company prior to the Carthage shutdown.

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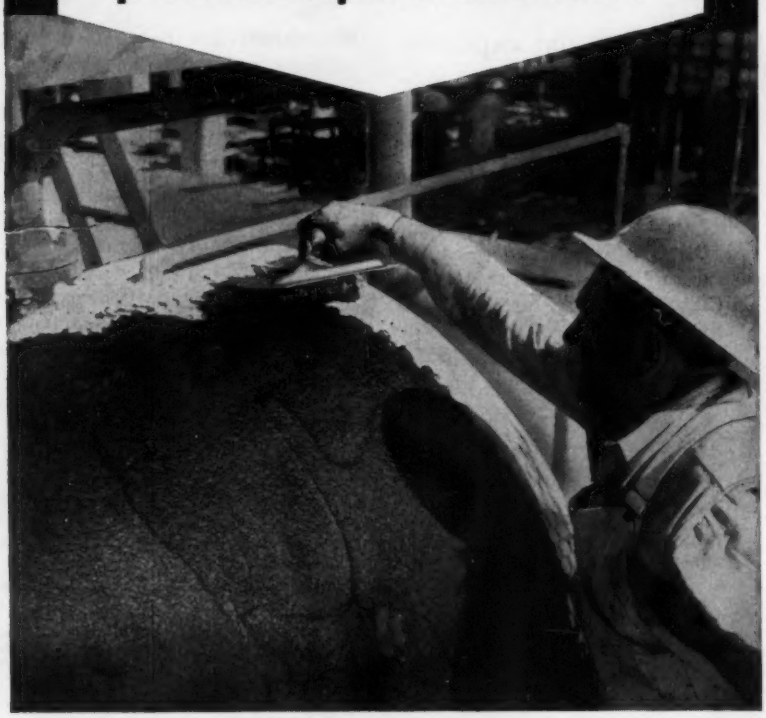

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What's Happening. . .

limited oxygen production to about 75 to 80 percent of design.

2. Revisions in the heat exchanger system and addition of one new exchanger to each unit.

Numerous other changes of lesser importance were also made.

Initial operation of the revamped oxygen plant in December, 1955, showed malfunctioning of the new heat exchangers. On the basis of the test results, the plant exchangers were modified in February, 1956. In subsequent operations both units met design requirements and operation of the oxygen plant was routine.

Synthesis Gas Generation

The original Brownsville plant included only one gas generator for producing synthesis gas. Repeated burner failures, soot deposits on cooling section, tubes, refractory failures, and other problems limited operations by Carthage. To provide continuous operations, an improved gas generation unit was installed by Pan American. The old and the new generators were equipped with improved burners in which the natural gas and oxygen were combined to produce the synthesis gas. One important burner modification was the addition of multiple burner control systems for accurate control of gas and oxygen. Maintenance of proper oxygen-to-gas ratio is important—otherwise, at high oxygen ratio, excessive flame temperature results, leading to metal and refractory failures; at low oxygen ratio excessive soot formations occur. Upon initial operation of the new gas generator in April, 1956, with successful operation for 111 days prior to shutdown, these problems were encountered:

1. Excessive soot formation, resulting in carbonaceous deposits on the burners.
2. Failure of burner parts due to corrosion.
3. Failure of the burner face refractory with exposure of the burner to excessive flame temperatures.

These problems and others were overcome and generator operation at rates and product yields well above design became routine.

Hydrogen Production

The water gas shift reaction was employed in a conventional unit, to convert carbon monoxide to carbon dioxide, followed by separation of carbon dioxide monoethanolamine. With several minor changes, this system was satisfactory at through-puts substantially above design values.

Catalyst Preparation

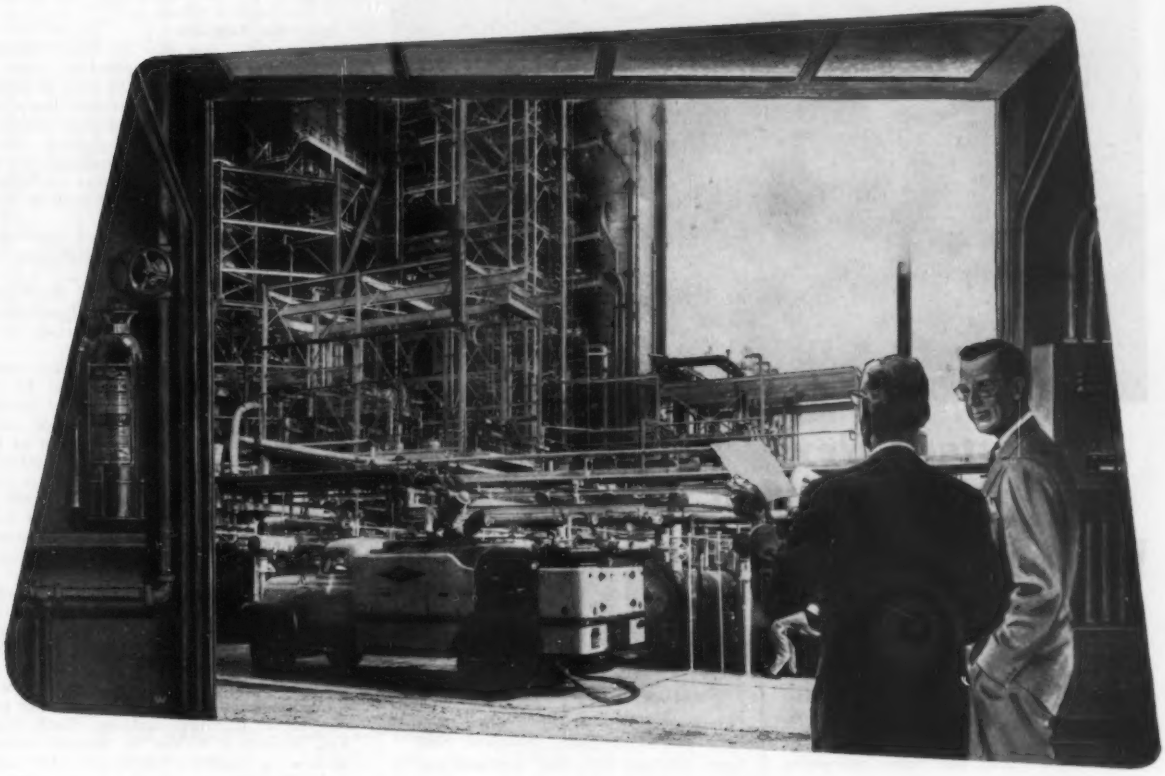
This system includes units for grinding, sizing, and chemical impregnation of powdered catalyst followed by reduction with hydrogen and treating (activation) of reduced catalyst with synthesis gas. A number of important revisions were made in the catalyst grinding and sizing unit and satisfactory operation was achieved.

The catalyst reduction step, in which unfinished catalyst is contacted with hydrogen under fluidized conditions, was modified as follows:

1. New reactor internals were provided to insure better gas-solids contacting.
2. A filter system was installed for recovery of catalyst fines from the reactor effluent gases.

The desired improvement in gas-solids contacting was obtained during early stages of operations by Pan American. However, much difficulty was encountered with the catalyst filter system. From an

Dowell Service Helped This Plant Profit By Saving $312,700 in Maintenance Costs!



To clean and service the giant catalytic crackers in today's modern refineries is quite a job . . . and very costly. Costly, that is, unless Dowell Service is on the job to help clean the "cats"—chemically. Here's an example of how Dowell chemical cleaning service cut turnaround costs for one refiner by $312,700.

Dowell was called in to provide cat cracker turnaround service which included the cleaning of: two flue gas coolers, two catalyst coolers, four overhead aftercoolers, one light gas oil cooler, one heavy gas oil cooler, two top tray reflux coolers, and two final gas condensers.

Dowell's time: thirteen and one-half hours; Cost: $2300.

It is estimated that this same cat cracker service, if done by mechanical methods, would have cost the refinery: 1) Additional downtime of seven days—$210,000; 2) Additional spare bundle inventory—$100,000; 3) Labor—$5,000.

The refinery enjoyed a $312,700 operating credit from this single cat cracker turnaround—not including expected efficiency increases.

Dowell provides expert service in removing scale and sludge from product, process and steam generating systems. Dowell does the job for you—furnishing all chemical solvents, trained personnel, pumping and control equipment. Furthermore, Dowell has the experience in chemical cleaning to provide assurance of a job well done.

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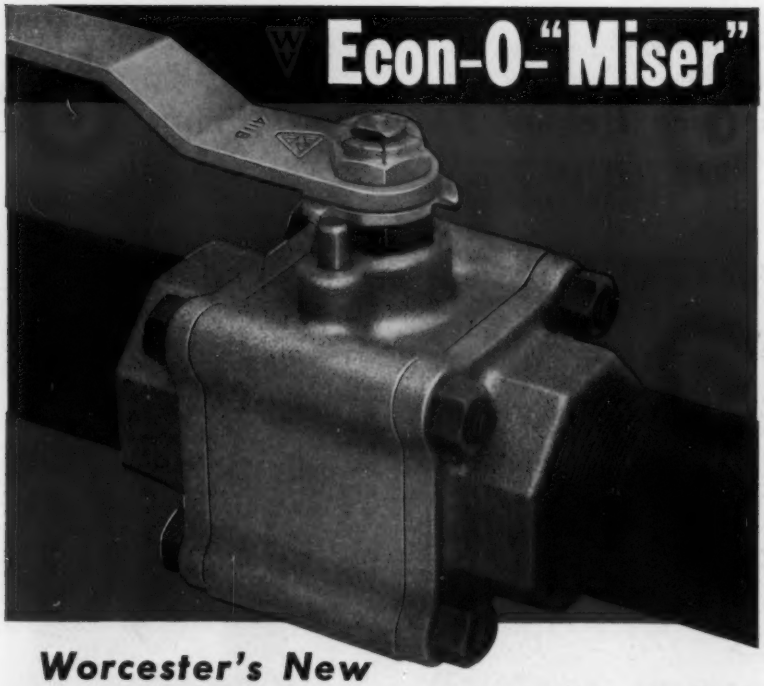

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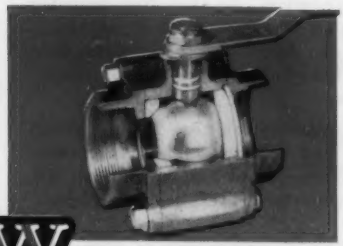
This great new advance in valve design can mean substantial savings for you. Its unique construction makes the Econ-O-"Miser" both ball valve and union in a line whether the application be original equipment, in-plant maintenance or process lines.

The costs of a union and installing it are eliminated, resulting in tremendous savings when the number of ordinary valves and unions in even a small installation is considered. Add to this the longer operating life of the Econ-O-"Miser", the time and materials savings of *in-line maintenance*, and you get performance unmatched by *any* valve at *any* price.



The Econ-O-"Miser" is available in Bronze, Aluminum, Aluminum Bronze, Forged Carbon Steel, Stainless Steel types 303 and 316. Seat and seal materials available: Teflon, Buna-N and Neoprene (others available on request.)

The many combinations of body and seat seal materials allow handling of exceptionally wide range of media.

Other Outstanding Features

- Compact for ease of installation
- Positive leakproof shut-off
- **In-line maintenance** permits quick, easy inexpensive repairs
- Two-way flow allows application of pressure or vacuum to either side of valve
- Quarter turn operation — readily adaptable to remote control
- Visual determination of OPEN — CLOSED positions — No manual check needed
- Round flow through the valve — minimum pressure loss and turbulence
- "Wiper-action" of resilient seat against ball eliminates abrasive wear due to foreign materials in media . . . assures leak-proof seal . . . long operating life

* Pat. Pending

Write for full particulars

WORCESTER VALVE CO., Inc.

15 PARKER STREET WORCESTER, MASS.

Ball, Gate and Needle Valves

What's Happening . . .

over-all viewpoint, all performance goals for the catalyst reduction unit were met or exceeded.

After initial operation, the unit satisfactorily prepared catalyst for the synthesis reaction step. However, major difficulties were encountered in the operation of the catalyst filters.

Synthesis Reaction

The plant has two 16.5-foot diameter reactors. In normal operation, each reactor contains 175 to 200 tons of catalyst in a fluidized bed. Each reactor has a multiple catalyst filter to separate entrained catalyst fines from the gaseous reactor products. Associated equipment includes heaters, compressors and heat exchangers, and catalyst storage and handling facilities.

This unit was modified and new equipment was added during engineering and construction as follows:

1. Replacement of the feed gas distributor and the reactor internals employed for removing the heat of reaction, to obtain better gas-solids contacting.
2. Installation of a new steam system for removing the heat released by the synthesis reaction. The original cooling system consisted of "bundles" of steam tubes capable of generating steam at 675 psi (500 F). Pan American installed a system which allowed variable steam pressure control over the range 675-1500 psi (500-600 F). This change allowed more precise control of the reactor temperature which is necessary for satisfactory catalyst life and good product yields.
3. Replacement of cyclones and addition of filters for separation of entrained catalyst fines from the effluent gas. The new single stage cyclones were of highest possible efficiency. The filter system installed for each reactor was designed with four separate filter vessels containing porous metal filtering surfaces. Each vessel had automatic valves to permit reversal of flow to remove accumulated filter cake.
4. Modification of the heat exchange equipment to provide for heat recovery from the reactor effluent gas.

The major problems encountered since initial operation in June, 1956, include:

1. Failures of the porous metal used in the catalyst filters, clogging, and other filter system difficulties.
2. Poorer gas-solids contacting efficiency than design, with catalyst deposition on the reactor internals.
3. Erosion of reactor internals.
4. Excessive catalyst losses.

Until recent months, the porous metal filters appeared to be the major limitation in reactor operation. The aspects include:

1. Mechanical failures which allowed catalyst to pass through the filters and into the heat exchange equipment. This resulted in malfunctioning of the heat exchange system.
2. Catalyst accumulation among the "bayonets" in each filter vessel (a bayonet is about four feet long and its cross section is elliptically shaped and about two and one-half inches wide), resulting in complete packing of catalyst within a filter vessel.
3. Carburization and embrittlement of the porous metal (type 316 stainless steel) used in the filter bayonets as a result of reaction with the carbon monoxide in the reactor effluent gas.

During these operations, reactor operating factor was about 30 to 35 percent.

The filter problem was solved by using

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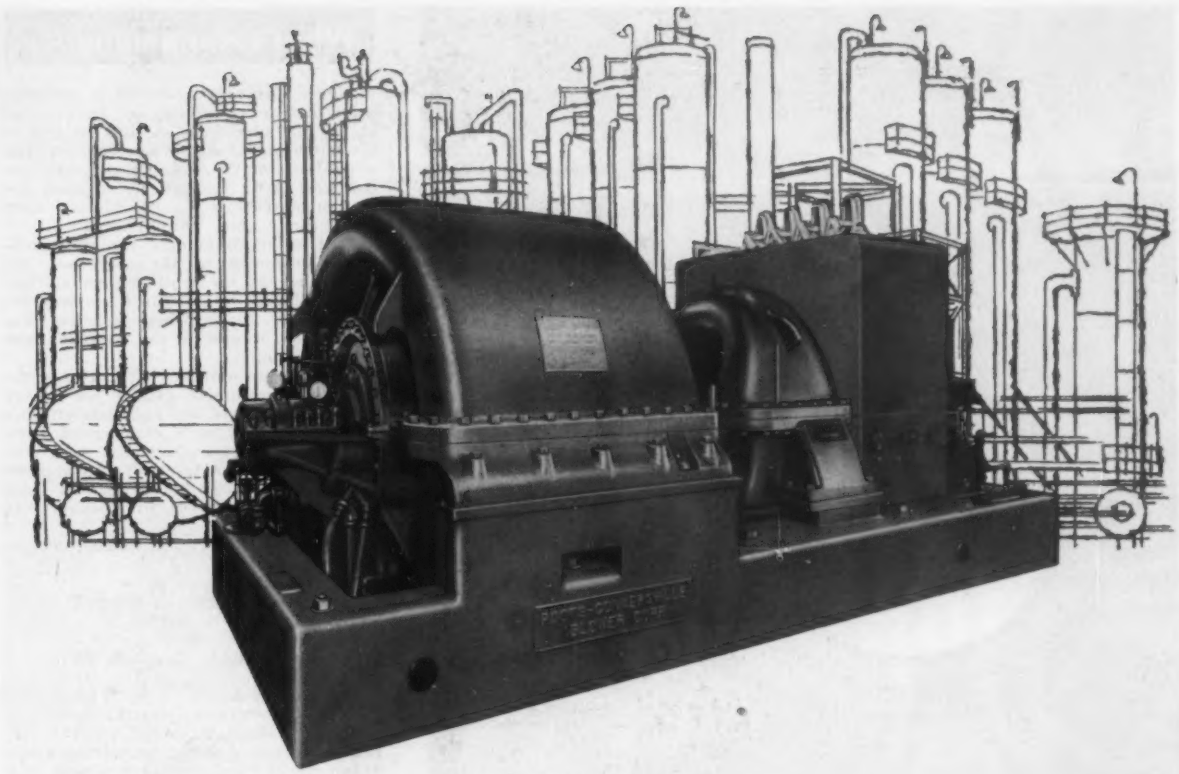

A DOZEN REASONS

1 **PROVED** — industry-wide installations.

2 **TEN FRAME SIZES** — 2,000 to over 100,000 cfm.

3 **DRIVE-THROUGH** — for maximum driver economy, simplified installation.

4 **EXTERNAL BEARINGS** — case supported housing. Saddle type, semi-rigid supports. Precision alignment built-in.

5 **OIL FREE AIR OR GAS** — air or gas stream never comes in contact with lube oil. No contamination.

6 **DIRTY GASES EASILY HANDLED** — R-C units are not fussy about a little entrained dirt. Casing drains permit quick wash-down.

7 **EXTRA-RUGGED CASE** — maximum resistance to pressure. Freedom from alignment problems.

8 **UP OR DOWN CONNECTIONS** — available on all cases. Allows greatest piping freedom and economy.

9 **CENTER LINE CASE SUPPORT** — simple to install, no support problems with down connected machines.

10 **FACTORY PACKAGED AND TESTED** — compressors tested with their own driver, R-C has a modern steam plant for test purposes.

11 **PROVED SEALS** — interstage and shaft seals to fit the application.

12 **SIMPLE TO MAINTAIN** — accessible external shaft bearings and double thrust bearing. Easy to inspect rotor and internal seals. Cases split at the horizontal center line.

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Unqualified mechanical dependability which assures continuous performance on the job under difficult operating conditions are inherent characteristics of Roots-Connersville centrifugals. They are the ideal choice when down-time cannot be tolerated.

Experienced Roots-Connersville engineers stand ready to tailor a multi-stage or single stage centrifugal compressor to your application. You can count on faster delivery too, due to a major expansion in manufacturing facilities. So, call in your nearest Roots representative who will gladly give you all the facts. Or write for Bulletin 120-B-14.

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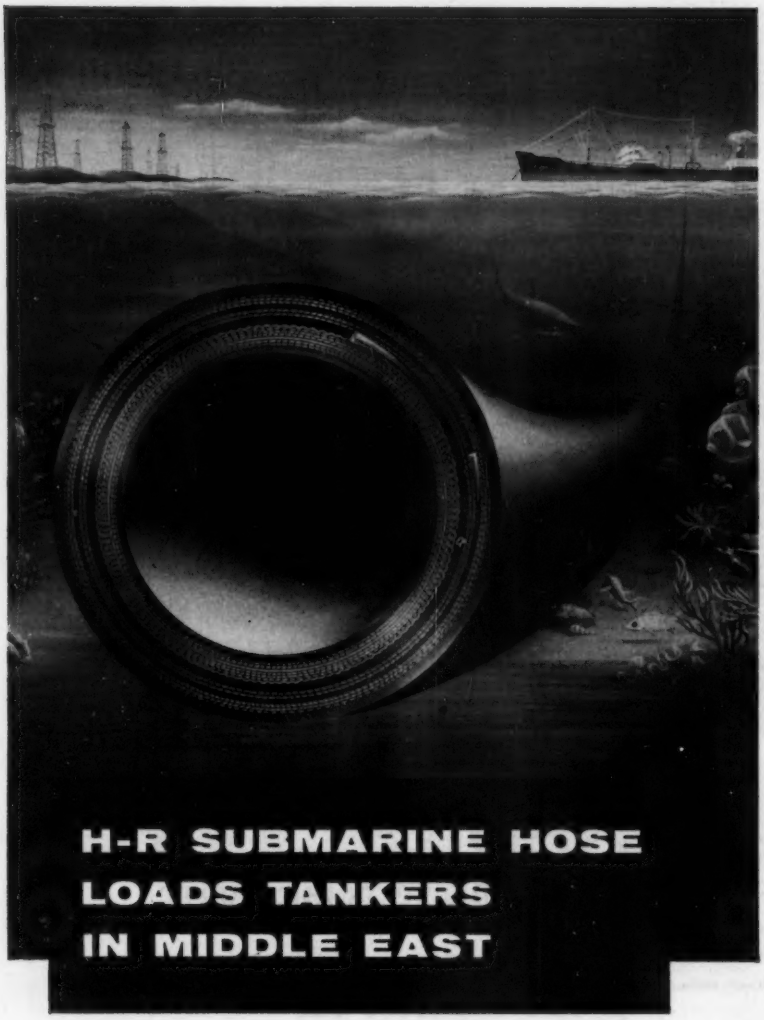

During several years of Eastern Mediterranean service for the Trans-Arabian Pipe Line Company, three lengths of Hewitt-Robins 12" Submarine Hose have loaded 1,295 tankers with 169,334,955 barrels of oil. Another length, in service six years, has loaded 1,603 ships with 232,713,229 barrels. This remarkable record is evidence of the extreme strength and flexibility of this sea loading hose. For it withstood constant flexing by wave-tossed tankers, the abrasive action of sand and silt, and the corrosive action of oil and salt water.

Also from Trans-Arabian come test reports of Hewitt-Robins 15¼" I. D. Submarine Hose. Results: increased loading capacity for today's super tankers. To find out how H-R products and services can help you, consult your classified telephone directory for the nearest H-R representative, or contact Hewitt-Robins, Stamford, Connecticut.

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CONVEYOR BELTING AND IDLERS...POWER TRANSMISSION DRIVES
INDUSTRIAL HOSE...VIBRATING CONVEYORS, SCREENS & SHAKEOUTS

What's Happening . . .

modified operating conditions to minimize some undesirable effects, and by developing a new type filter medium to replace the porous metal used in the bayonets. The new filters employed glass fibers with carbon steel. With this system, sustained operation of reactors was possible and filter maintenance costs were reduced.

With a few differences, the filter problem is common to the reduction, the activation, and the synthesis reaction systems. Solution to the filter problem developed for the synthesis reactors was successfully applied to the reduction and activation units.

Despite improvement over Carthage operation, deposition of catalyst on reactor internals, hot spots, and high catalyst fines production rates were experienced from the start of reactor operations. Also, erosion of the reactor internals was a problem in early runs. Many changes were made to the plant reactors to overcome these difficulties.

Results from a typical plant run are summarized below:

Length of runs, days	50
Feed rate, percent of design	100
Average yields, percent of design	
Water-soluble chemicals	90-95
Stabilized oil	80-85
Polymer gasoline	80-85

At shutdown time, reactor operating factor was about 60 to 65 percent. Although the actual reactor performance was below expectations, the performance was considered acceptable for this stage of process development. Operational data indicate that most differences in past reactor operations as compared to design result from deficiencies in the gas-solids contacting within the reactor.

The activation reactor is a smaller (eight-foot diameter) unit which may be operated as a synthesis reactor. For several months, the problem of gas-solids contacting was investigated in this reactor. Revisions were made to the reactor internals whereby improved gas-solids contacting was achieved. Also catalyst losses were reduced to a negligible value. This work was confirmed in runs in the activation unit.

Summarized results from a typical test in the activation unit follow:

Feed rate, percent of design	100
Average yields, percent of design	
Water-soluble chemicals	103
Stabilized synthetic oil	92
Polymer gasoline	93

With further minor revision, design yields may have been obtained in this smaller reactor. Some recent developments have shown equal or greater promise than those already proven in the activation reactor. These developments were being tested when the plant shut down.

Several months ago, designs were completed to permit translation of results from the activation reactor to the larger synthesis reactors. The over-all results indicate that technical feasibility of the hydrocarbon synthesis reaction with fluidized catalyst has been demonstrated.

Product Recovery

This section of the plant, with some additions, is comparable to the absorption and stabilization units used in natural gasoline and refinery operations. This section performed satisfactorily in all operations.

Liquid Treating (Isoforming)

This unit, a 5000 bpd Isoformer, is a

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HERE ARE THE TEST PHOTOS:

This is a Rockwood Spot Protection System discharging FogFOAM at a pipeline pumping station. Fire could break a link in the pumping system which could interrupt or stop refinery production. The Rockwood System goes off automatically by a rate-of-rise detection system and protects against such an eventuality.

Here's the same scene from another angle after only 3 minutes of the Rockwood Protection System operation! There's a four inch blanket of Rockwood FogFOAM on the floor — and there's no longer any danger of flashfires starting.

Rockwood FOAM delivers four inches of fire protection *in three minutes!*

Rockwood FogFOAM systems *instantly and automatically* discharge FogFOAM to the fire area where it forms a fast flowing heavy blanket of FOAM. Within seconds of the fire's start Rockwood FOAM literally covers the fire and strangles it. Flashbacks are prevented.

Write for full information on how your plant can be spot protected against costly flammable liquid fires by Rockwood precision engineered fire-fighting equipment. Send for your booklet now —

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Engineers Water . . . to Cut Fire Losses

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fluid catalytic cracker for treating synthesis liquids. The isoformer and its equipment required few modifications during engineering and construction. The unit performed satisfactorily in all operations.

Catalytic Polymerization

This unit employs the California Research Corp. process for polymerization of light olefins to produce gasoline. Liquid phosphoric acid is used as catalyst.

The unit performed satisfactorily; however, tests were not conducted at design conditions because of feed stock limitations. No important technical problems were encountered in this section.

Water-Soluble Chemicals Plant

Operability of the water-soluble chemical recovery unit was demonstrated. Subject to feedstock limitations, the plant was operated satisfactorily since June, 1956 to produce these products:

Acetic acid
Propionic acid
Acetaldehyde
Propionaldehyde
Acetone
Methyl ethyl ketone
Methanol
Ethanol
Isopropanol
n-Propanol
Isobutanol
n-Butanol

Utilities

1. Steam: the plant has three 220,000 pounds per hour gas-fired boilers which generate superheated steam at 600 psi.

2. Boiler Feedwater: the original plant contained four salt-water evaporators, each rated at 25,000 pounds per hour of condensate. These units were modified and two new improved units were installed. All performed satisfactorily.

3. Cooling Water: Carthage utilized six salt-water pumps, with a combined capacity of 144,000 gpm, for cooling the process streams. Modifications included deepening and widening the inlet water channel and installing new facilities for chlorination of sea water. One new 34,000 gpm salt-water pump was also installed. This system performed satisfactorily.

4. Electrical: two 2500 KW electrical generators were in the original plant. Pan American made many modifications to the electrical distribution system to prevent power failures which were previously encountered. In general, this system performed as anticipated.

5. Fuel Gas: the fuel gas system is unchanged from Carthage operation.

6. Catalyst Disposal: the disposal of used catalyst from the synthesis reaction step was difficult during Carthage operation. Pan American installed a hydraulic system to transfer this catalyst to disposal pits away from the plant. This system proved satisfactory.

Economic Aspects. Three main factors prevented attainment of the goals established in 1954 for the Brownsville plant. They are:

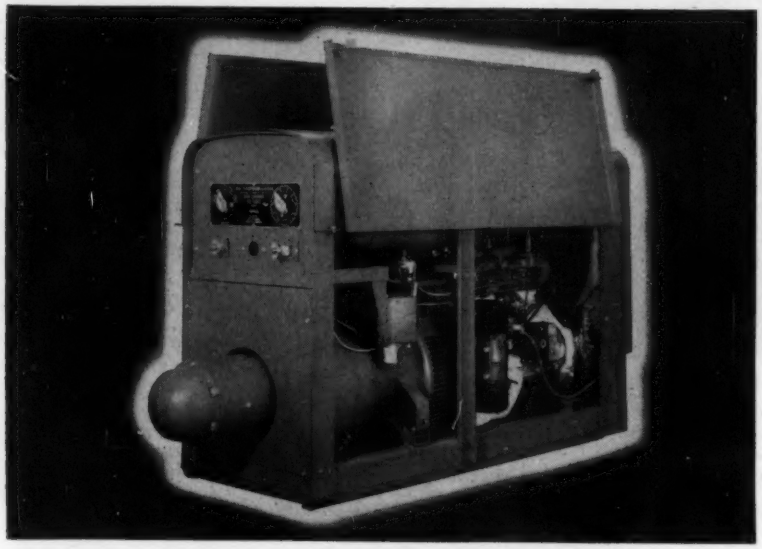
1. The repairs and modifications of the Carthage plant and the installation of new equipment took much more time and money than had been anticipated.

2. After operations were begun, it was necessary to develop solutions to the major technical problems previously discussed. During this time, normal operating costs continued with little off-setting income from production.

3. Rising costs of equipment, labor, and raw materials without corresponding increases in product prices.

This article has reviewed the more important operating problems of the Brownsville plant. In general, solutions to these problems were found. Based on tests in an eight-foot reactor, it appeared that development of a practical solution to the last major problem—good gas-solids contacting—was nearing completion. However, even at lined-out conditions the plant would have cost substantially more to operate and maintain than had been forecast.

It was contemplated in 1954 that if the plant was operable, it would be expanded to a level which would result in a satisfactory financial return to the company. A number of alternate routes of expansion have recently been studied. Detailed studies indicated that if expansion were begun now, capital investment would be about two-thirds greater than estimated in 1954. The rising costs of equipment and labor are an important factor in this change. Also, operating costs for the plant would be appreciably greater than forecast in 1954. There also has been an increase in the cost of natural gas while prices of the gasoline and chemical products are essentially unchanged. A similar situation existed for other expansion routes, including the utilization of hydrocarbon products for chemical manu-



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(at the same low price)

Shield-Arc 200 has these new features

Extra Horsepower—New 36 h. p. Continental engine (at the same low rpm) insures top output after thousands of hours of continous, hard use. Also gives full welder performance at high altitudes.

Large Gas Tank—16 gallon capacity allows operation for full 8-hour shift without refueling.

Precise Current Control—Shield-Arc's famous dual control made even more accurate by increasing steps of current selections.

Rugged Base and Housing—Heavy gage steel base, top and doors, and extended housing protects welder from damage through rough use in the field.

Complete specifications are contained in Bulletin SB-1337. Write for it.

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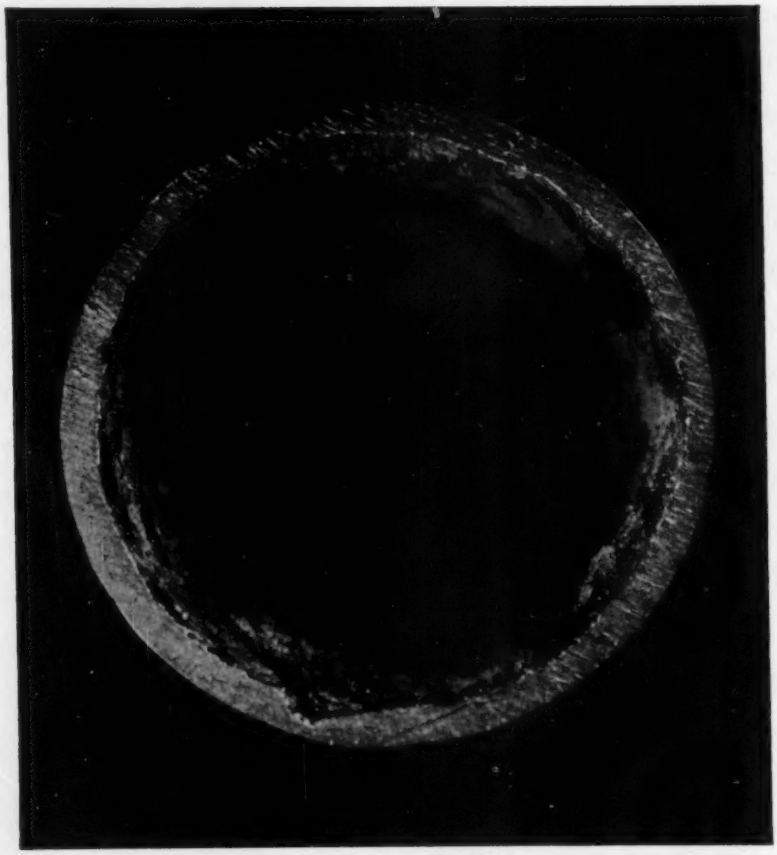
what's your plant water problem?

■ CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

BETZ LABORATORIES INC., Philadelphia 24, Pa.



Using vertical polarized light on a cross-section of pipe, photographer Bernard Hoffman clearly shows the ravages of corrosive action.

Controlling Corrosion in Fluid Engineering

Corrosion seldom works alone. Together with heat, pressure and abrasion factors, it compounds the problems of fluid engineering. But when you have valve design problems involving corrosion, you can look to the engineering leadership available at S. Morgan Smith for assistance.

You can use R-S Rubber-lined Butterfly Valves, for instance, to handle many special applications. The rubber lining protects the entire valve body, gives you corrosion resistance with maximum economy. Where your processing problem demands additional engineering, you can draw on the broad SMS background of experience in specialized valve applications.

There is a complete SMS line – Rotovalves, R-S Butterfly Valves and Ball Valves – to meet your fluid control problems. To obtain full information, contact our nearest representative, or write S. Morgan Smith Company, York, Penna.

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What's Happening . . .

facturing. The combined effect of all of these factors made the project unattractive from an economic viewpoint, thereby dictating shutdown of the plant.

Sohio's Latonia Refinery To Make Asphalt Only

Sohio's Latonia, Ky. refinery is now to be operated chiefly for the production of asphalt and asphaltic products. This decision was based on the growing market for asphalt, especially in connection with the nation's road-building program, plus the fact that increased capacity and more modern facilities in other Sohio refineries makes it unnecessary to make finished gasoline at Latonia.

"The move merely confirms a shift in operations that has been developing here over the last two years," Ray Elo, manager of the Latonia Refinery, said. "We have been making less finished gasoline, and more asphalt products. We will continue to make some jet fuel, diesel oil and gasoline components."

Voluntary Oil Imports Plan Draws Company Grievances

Late estimates indicate that a great deal of progress will be made in reducing oil imports during the next four months. Success of the voluntary program can be assured, however, only through the continued support of the importing companies, Imports Administrator Carlson said early this month.

"The degree of cooperation with the government that already had been assured encourages me to look forward to its complete success," he added.

Some companies still contend that there are inequities in the voluntary oil import restriction program. The following is a brief run-down on those companies, and what they want.

Indiana Standard opened the Interior Department's hearings into the alleged inequities last month with a request that its own allocation be upped 60 percent from the proposed 29,800 bpd to 53,500 bpd.

Eastern States Petroleum asked Carlson to boost its recommended "quota" from 18,300 bpd to 22,800 bpd—on the basis of contract commitments made before the Cabinet committee's report. At the same time, the company also blasted "inconsistences" in the government policy which permit the defense department to make substantial jet fuel awards to Caribbean refiners at the same time voluntary import restrictions are sought (related story follows).

International Refineries hearings took place as the result of a miscalculation of the company's programmed imports by government officials and failures of the Office of Defense Mobilization to solicit updated forecast from firm in July, the company declared.

Sinclair challenged the need for government-sponsored crude oil import restrictions and hinted that it might not comply with the voluntary program.

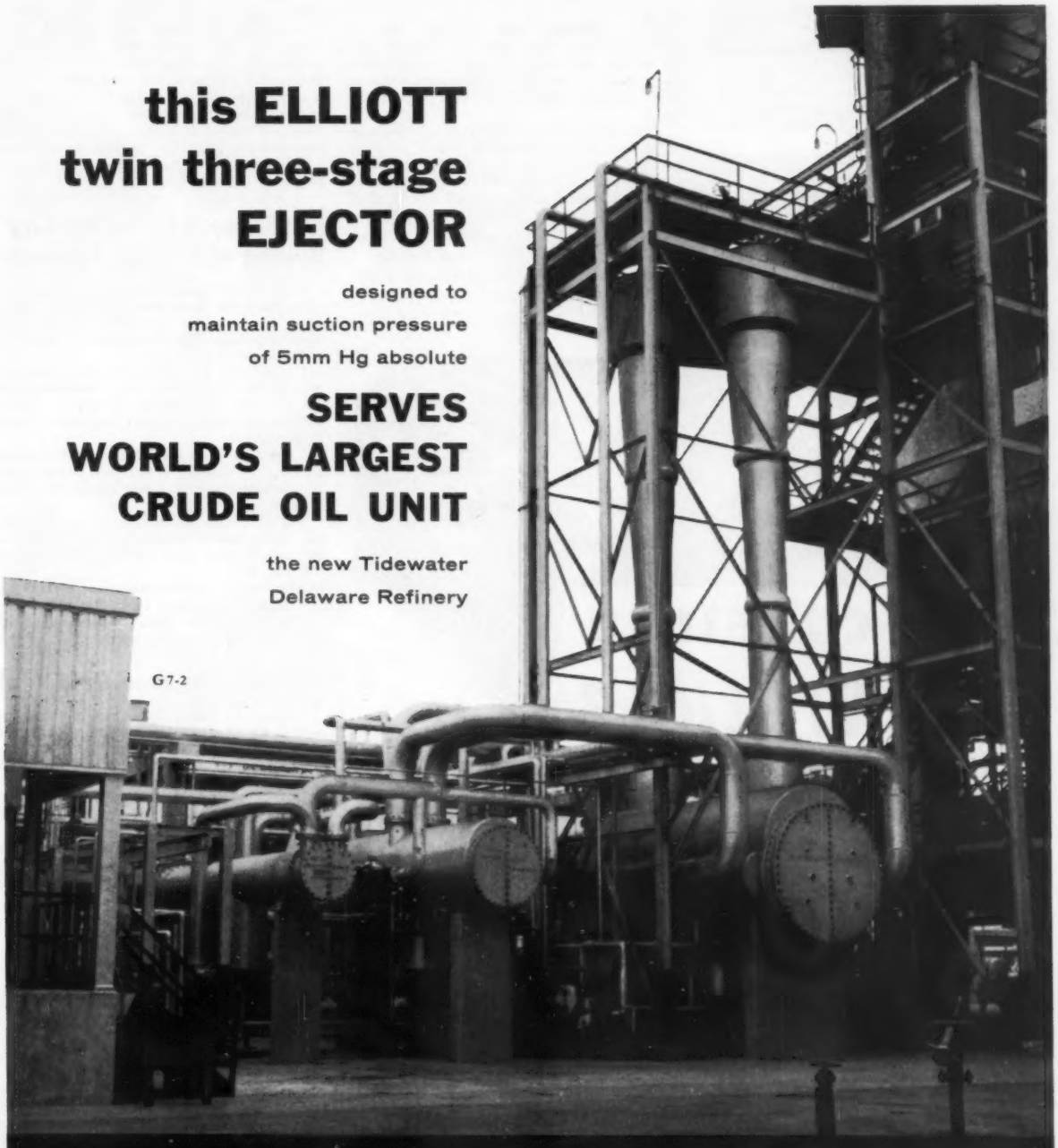
J. E. Dyer, president of Sinclair Refining, told Carlson that his company would need 74,000 bpd rather than the 62,200 recommended by the Cabinet committee.

this ELLIOTT twin three-stage EJECTOR

designed to
maintain suction pressure
of 5mm Hg absolute

SERVES WORLD'S LARGEST CRUDE OIL UNIT

the new Tidewater
Delaware Refinery



The giant-sized Elliott twin ejector is the largest vacuum installation ever built. It was designed to maintain a suction pressure of 5mm Hg abs and uses approximately 85,000 lb of steam per hour. The two vertical first-stages have 60-in. diameter inlets and are 40 ft long. They discharge to the 20,000-sq ft intercondenser on the right. Two 20-in. second-stage ejectors discharge to the 6000-sq ft intercondenser in the center. The 3000-sq ft aftercondenser is seen on the left.

Elliott builds steam jet ejectors in a complete size range, single-stage and multistage, to serve all sorts of chemical and industrial processes requiring the use of vacuum.

ELLIOTT

Company

JEANNETTE, PA.

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What's Happening . . .

Dyer also said that Sinclair will not make any commitments supporting the program until company's appeal for higher quota is ruled upon by Carlson.

Northwestern Refining will abide by the government's formula through June, 1958 if data to which formula applies are correct. Discrepancies arose because Office of Defense Mobilization slipped up, and failed to request new forecast of imports from the company in July, although other importers were queried. ODM, therefore, relied upon "older and obsolete" projections which were 3000 bpd short of Northwestern capacity.

Ohio Standard told Carlson that it would adhere to the quota set for the last six months of this year, but that it wants its allocation for the first six months of 1958 boosted from 8200 bpd to 13,500 bpd.

Tidewater Oil said that an insistance on a 34,200 bpd allowable would amount to "confiscation" of the company's East Coast refining facilities. President D. T. Staples said that the company would need an allotment of at least 62,000 bpd during second half of 1957 in order to stay competitive with other East Coast refiners.

Meanwhile, Gulf Oil interjected a different note into the scene by declaring in a statement filed with Carlson that the voluntary program may be jeopardized if substantial increases are granted those companies requesting them. Gulf cited examples of hardships which it would suffer under the program, but stated that it was willing to go along with what had already been proposed. On the other hand, it stated that any action to change the current program "would require Gulf to reevaluate its earlier decision to comply with the request."

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(25% to 50% Lower)

FOR COMPARABLE CAPACITY? . . . . YES!
(Equal or Better Than Conventional Designs)

FOR HIGHER EFFICIENCY? . . . . . YES!
(Closer Approach to Equilibrium)

FOR MAXIMUM FLEXIBILITY? . . . . YES!
(Wide Operating Range)

FOR MINIMUM MAINTENANCE? . . . YES!
(Simplified Installation, Self-Cleaning Characteristics)

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Designers, Builders, Fabricators of Heat Resisting Alloy and Stainless Steel Equipment

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U. S. May Review Military Buying of Foreign Products

Government petroleum planners may review military purchases of foreign petroleum products for use in U. S. as guard against possible circumvention of voluntary crude imports program.

Complaints have been received that military product purchases from Caribbean and other areas are hurting domestic refiners in same manner as alleged "excessive" crude imports.

Under present law, Military Petroleum Purchasing Agency is required to buy products at lowest cost to government, regardless of source.

MPSA hopes to "equalize," where possible, its cutbacks against existing contracts in order to keep from seriously injuring any one supplier.

Meanwhile, agency expects to award contracts for full amount of jet fuel advertised under IFB 57-148. Small business set aside also will remain unchanged.

Refinery Workers Paid Well

Bureau of Labor Statistics has released new study of effect upon refinery personnel of technological changes.

"Refinery workers are among the highest paid production workers in American industry. Weekly earnings averaged over $108 in 1956, and hourly earnings, $2.65, compared with the average of $80.19 a week and $1.98 an hour for all manufacturing. Since 1947, hourly earnings have risen by 69 percent, compared with 60 percent in manufacturing as a whole."

API Streamlines Schedule

A streamlined program, one day shorter than usual and changed materially in the way its sessions have been rearranged, is in store for approximately 7000 oil men and their guests who plan to attend the 37th Annual Meeting of the API in Chicago next month.

The general session that normally takes place on Thursday morning has been switched to Monday afternoon—the first day of the meeting. Thus, all that is left on the Thursday morning schedule is a single committee meeting.

The preliminary program for the Division of Refining is as follows:

TUESDAY, NOVEMBER 12, Refining Session, Conrad Hilton—Grand Ball Room. Presiding, H. W. Ferguson, vice president API; vice president, Humble Oil & Refining Co., Houston.

Report of Division's Nominating Committee—H. W. Field, The Atlantic Refining Co., Philadelphia, Chairman.

Election of members of the general committee of the Division of Refining.

General Consideration of Static Electricity in the Handling of Petroleum Products; W. M. Bustin, T. L. Culbertson, and C. E. Schleckser, Jr., Esso Research and Engineering Co., Linden, N. J.

Theoretical and Experimental Observa-

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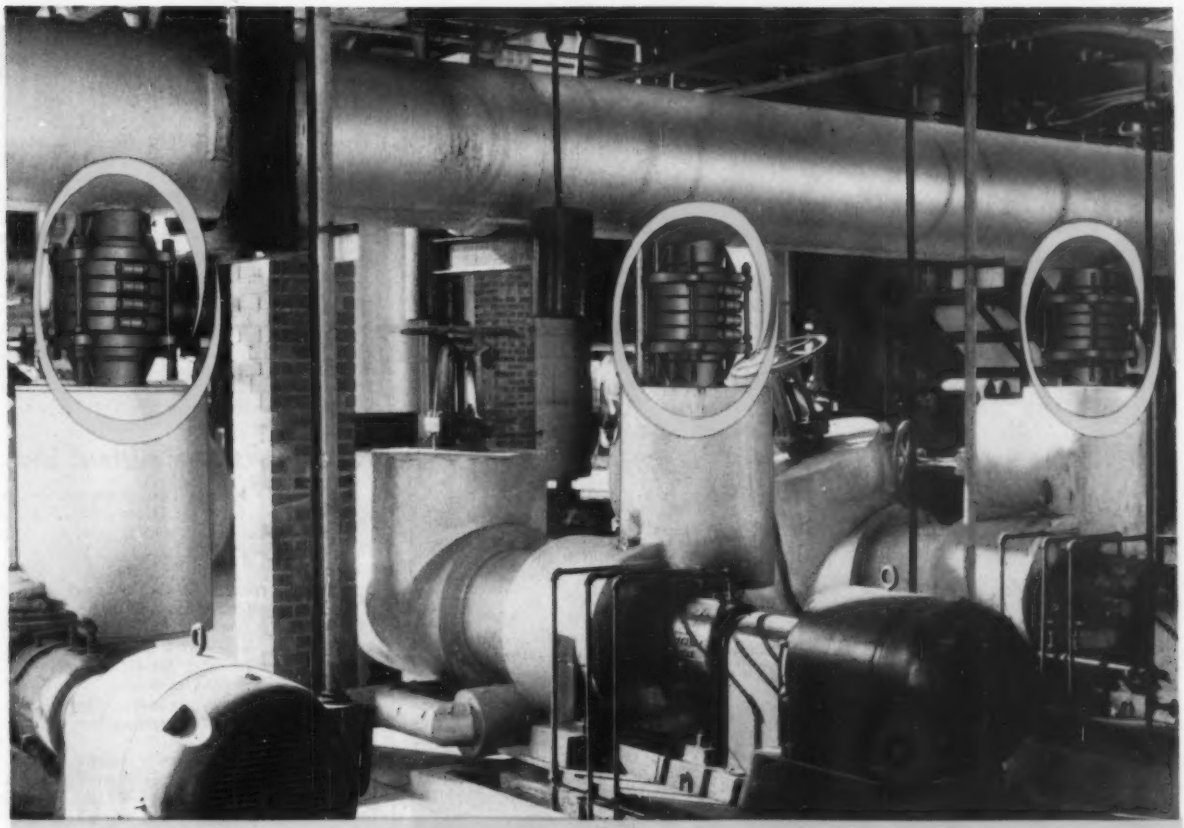

ADSCO CORRUFLEX EXPANSION JOINTS SOLVED A PIPING PROBLEM FOR NATIONAL ANILINE

The new $20,000,000 diisocyanates plant of the National Aniline Division, Allied Chemical & Dye Corp., at Moundsville, W. Va., is known for many engineering wonders, especially its miles of intricate piping. The photo above shows three ADSCO Corruflex anti-compression packless expansion joints used to secure satisfactory piping connections between the main piping and three pumps.

If rigid piping had been used to connect the three pumps to the 18-inch main feeder, the piping soon would have been twisted and overstressed by the growth of the main feeder when hot process liquid was pumped through it. National Aniline engineers, in consultation with ADSCO engineers, decided to use the anti-compression joints shown in the photo. These are deflected laterally with minimum strain on the connecting piping and pumps as the main feeder expands or contracts. Also, the joints absorb vibration of the pumps and motors.

For efficient, right-working pipe line arrangements, use ADSCO Corruflex expansion joints. Packless, they require no maintenance. Sizes, 3" to 54"; for temperatures to 1600 F and pressures to 300 psi.

REMEMBER! Use ADSCO Expansion Joints instead of Pipe Bends because of these advantages:

1. Less Heat Loss 2. Less Pressure Drop 3. Less Space 4. Less Cost

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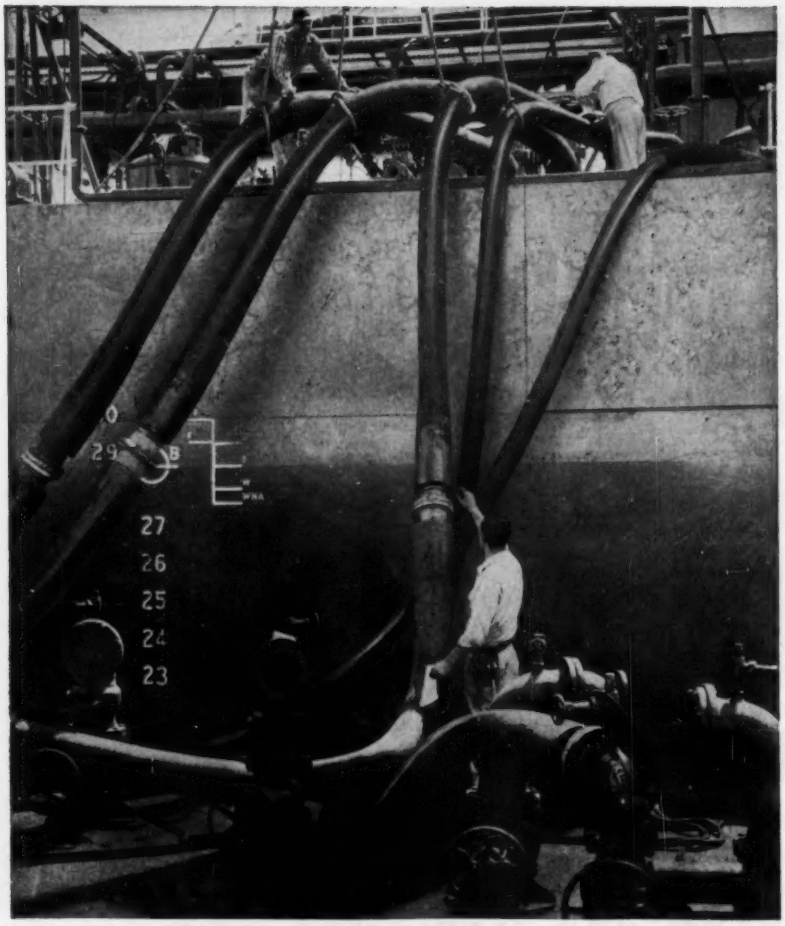

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for loading and unloading oil and gasoline from barges and tankers!

- *Won't kink or crush!*
- *Won't expand under pressure!*
- *Won't collapse under suction!*
- *Superior construction due to nylon cord reinforcement!*

For more information about new Quaker Qua-Flex Oil Transportation Hose—flexible, lightweight and rugged—see your Quaker Rubber distributor today!

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QUAKER RUBBER DIVISION

What's Happening. . .

tions of Static Electricity in Petroleum Products. J. P. McDermott, J. C. Munday, and D. T. Rogers; Esso Research and Engineering, Linden, N. J.

Laboratory and Plant-Scale Experiments on Static Electrification, Its Generation and Prevention; A. Klinkenberg, N. V. Bataafsche Petroleum Maatschappij, The Hague, The Netherlands.

Use of Raadioactive Material to Reduce Static Electricity Inside Storage Tanks; J. J. Conradi, J. J. Skelly, and James R. Miller, Shell Oil Co., Wood River, Ill.

Committee meetings for the Refining Division are scheduled for Nov. 7-12.

Navy Asks Shale Plant Bids

Office of Naval Petroleum Reserves will advertise for bids from private companies to conduct research activities at Rifle, Colo., oil shale plant.

Capt. A. S. Miller, USN, director of petroleum reserves office, testified before House Armed Services Committee last spring that Navy-supervised research program would cost about $13.5 million for five-year period and would be directed primarily at retorting processes. Additional three-year research program costing $4.5 million could then be undertaken to test shale oil fuels.

Contracts for research must be approved by armed services committees on both sides of Congress. Vinson group favors Navy program, but contracts may run into trouble on Senate side, where Senators O'Mahoney (D-Wyo.) and Carroll (D-Colo.) have introduced bills calling for renewed research activities at Rifle by Bureau of Mines.

Must Keep Public Informed

A public opinion expert told the petroleum industry that it, like all other businesses, must face up to a "new type of competition whose skill is not in producing and distributing, but in talking about things."

Dilman M. K. Smith, vice chairman of the board, Opinion Research Corp., Princeton, N. J., said in a speech to the 55th annual meeting of the National Petroleum Association in Atlantic City. "Yours is a double responsibility, not only to render good economic service, but to defend and interpret it.

"If I can leave one thought with you, it is: 'Never make the mistake of assuming that good deeds speak for themselves. If you want people to think well of you, render them a good service—but also be sure you tell them about it.' "

Pemex Reshuffle Urged

Reorganization by government and private industry has been urged by Juan Sanchez Navarro, president of National Chambers of Commerce. The suggestion was made following a previous criticism that Pemex produces half as much petroleum with nearly six times more employes than operations by foreign oil companies.

Antonio J. Bermudez, Pemex director defended government-controlled operations, pointing out that a more "logical" approach to Pemex difficulties would be price-hike for its products. He said that Navarro's

For more data on advertised products, use Readers' Service Cards, last page.

Booming high octane market spurs alkylation...

Monel resists HF corrosion... permits safe, non-stop operation for a year or more

Boosting pool octane values calls for quantity as well as quality in the premium fraction.

So, in HF alkylation, the heat's on for (1) high-stream velocity and (2) non-stop operations.

But with increases in stream velocity, the HF corrosion rate may go up. Without special protection, more inspection shutdowns are called for.

To get around the impasse producers rely on Monel

Major operators have increased their onstream time to a year or better by using Monel* nickel-copper alloy freely in critical equipment. One company reports a two-year inspection schedule.

These companies depend on Monel alloy to resist both aqueous and anhydrous HF attack at elevated temperatures and pressures.

In acid regenerators, steam reboilers, feed pre-heaters, condensers, fractionating towers... Monel alloy or Monel-clad construction provides years of trouble-free life.

In valve, pump, and instrument parts with close tolerances, it eliminates undesirable build-up of corrosion products. As relief valve rupture discs and gaskets, it helps assure safe operation.

Chances are, Monel alloy could help you increase throughput and operate safely over longer periods.

Look into the matter today. Write Inco's Corrosion Engineering Section.

*Registered trademark

When to consider Monel for HF alkylation equipment. Monel nickel-copper alloy provides useful resistance to HF in all concentrations and (in unaerated solutions) up to 250°F. It is used with the anhydrous acid at temperatures up to 1100°F. Monel is comparatively unaffected by high stream velocities. Its strength and wear resistance are high.

INCO TRADE MARK **Nickel Alloys**

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Monel ... for minimum maintenance

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What makes a NEW business prosper in a highly competitive market?

To be successful in a market where competition is keen, it goes without saying that any business — particularly any new business — must have (1) Able Management, and (2) An Efficient, Well-staffed Plant. But most important of all, it must produce *Superior Products* that can be sold at *Competitive Prices.*

SMITH VALVES were introduced to the Refinery, Chemical, Petrochemical and Process Industries only two short years ago, yet they are already enthusiastically endorsed and used today by a large portion of the major companies in these industries. We offer this ready acceptance as *conclusive evidence* that SMITH VALVES are better . . . better because they are especially designed and precision built to overcome the problems of ever-increasing pressures, temperatures and corrosion . . . because they give longer, trouble-free life in service at lower maintenance cost. And remember, too, they cost no more than other makes of standard small utility valves.

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Smith "Figure 850" Inside Screw Valve
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800 SMITH FORGED STEEL
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What's Happening . . .

statement erred in facts and appreciation of Pemex's accomplishments under financial hardship of having to "practically subsidize Mexican industrialization."

It has been reported that Bermudez will run for president of Mexico in the 1958 elections.

Caltex Helps Refugees

The United Nations Relief and Works Agency for Palestine Refugees in the Near East announced recently that California Texas Oil Co., Ltd. (Middle East) was to contribute about 35,000 gallons of kerosene to UNRWA during 1957. Donation was to come from the Caltex Medreco refinery at Saida in Lebanon with distribution to begin in November. The gift intended for Palestinian refugees living in camps in Lebanon, is first of its kind by an oil company operating in the Near East area.

Computers Cut Design Time

Esso Research and Engineering Co. has reported that by using techniques involving electronic computers it expects to save about $1 million in the design and construction of a petroleum refinery.

Engineer John W. Kellett said at an American Chemical Society meeting recently that the use of a computer also cut the basic engineering time and manpower for the project by at least one-half. This work was completed three months earlier than if it had been done by hand, he reported.

Octane Numbers Up Again

Gasoline on sale at service stations in September showed national weighted averages of 98.2 octane number for premium and 90.9 octane number for regular, according to the latest monthly survey compiled by Ethyl Corp.

The premium average was 0.1 octane number higher than August and 1.2 octane numbers above a year ago. The regular average was unchanged from August but 0.8 octane number higher than a year ago.

Average tetraethyl lead contents in September were 2.59 ml per gallon of premium gasoline and 2.24 ml per gallon of regular gasoline.

Navy Unveils Portable Plant

Navy Department has removed secrecy wraps on a complete oil refinery that can be transported by air and placed in operation in less than two days.

The refinery is "one of the more interesting and sensational projects" being developed by the Bureau of Yards and Docks, the Navy admits in an exclusive article in the *International Oilman*.

The portable refinery can be dismantled into six basic components, carried by aircraft or other conventional transportation equipment. It has an aggregated weight of only 50 tons, and comes in components easily handled by ordinary oil field trucks.

Built by The Lummus Co., New York, the refinery's performance over a four-year period has exceeded requirements substan-

Easy, Quick to Install

Regardless of your requirements, Glitsch "Truss-Type"® Trays will save time and money for you in the long run. Inspection and maintenance operations are simplified because the tray sections are easily removed without disturbing the supporting members. Glitsch trays are designed with as few parts as practicable, and each assembly is standardized as far as possible, to reduce fabricating costs and installation time, and to simplify furnishing replacement parts. Glitsch trays allow the use of lightweight alloys, yet provide the maximum strength and rigidity for the tray sections. The "Truss-Type"® design also allows a wider distribution of available materials when critical corrosion-resistant alloys are required throughout an entire vessel.

Glitsch trays can be adapted to any process requirement, any flow type, vessel size, and layout, without sacrificing any features of installation or removability. Trays can be furnished with virtually any type of downcomers, weirs, wells, and cap and riser assemblies.

If you would like to verify how Glitsch "Truss-Type"® Trays can save time and money on your own projects, ask our nearest representative for a copy of our Catalogs No. 150 and 156, or write to Fritz W. Glitsch & Sons, Inc., P.O. Box 6227, Dallas, Tex. There is no obligation, of course.

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Glitsch (Sectional) "Truss-Type" Trays

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening. . .

tially, according to the authors, M. C. Lorenz and R. F. Berger. It is a simple topping plant of compact construction, designed to process 1000 barrels of crude oil daily.

The unit was intended to produce 11,500 gallons of motor-grade gasoline, 6300 gallons of aviation jet fuel, 7854 gallons of diesel fuel and 22,974 gallons of residuals for fuel and runway paving purposes.

Performance tests have included commercial runs lasting for over a year in which the refinery exceeded designed capacity by as much as 60 percent with the products being acceptable market grades, the authors reported.

Ethyl Gives 19 Scholarships

The award of 19 graduate research fellowships and five undergraduate scholarships at 24 leading colleges and universities have been announced by Ethyl Corp. Total value of Ethyl's fellowship-scholarship grants is $50,000. The company scholarships, designed to supplement the student's own resources, pay up to $800 at tax-supported institutions and up to $1,200 at private institutions. Most of the fellowships carry an additional $1500 for living expenses plus an allowance for tuition and fees. In addition, the university department concerned receives $500 for expenses in connection with the fellow's research work.

The newest awards mark the 21st consecutive year that Ethyl Corporation has provided graduate research fellowships.

NATIONAL IRANIAN OIL COMPANY

179 FRANCE AVENUE

TEHRAN, IRAN

1st September, 1957

The National Iranian Oil Company hereby informs all interested persons and Companies that, in accordance with the provisions of the Iranian Petroleum Act of July 31st, 1957, any inquiries, requests for information, or proposals of any nature whatsoever in connection with the performance of petroleum operations in Iran must be addressed direct to:

The Chairman of the Board of Directors,

NATIONAL IRANIAN OIL COMPANY,

Avenue France,

Tehran, Iran

Any communication made through other channels shall have no effect.

— Changing Times —

Russian Academy of Science claims to have **transformed gasoline into a solid.** Report states gasoline bricks are **produced by mixing normal-octane gasoline with plastic compounds in special equipment,** then solidifying mixture under heat and pressure. Bricks are reportedly heat and water resistant.

Great Northern Oil's Pine Bend, Minn., refinery is **back on stream following boiler explosion and small fire.** Fire was confined to 200-300 barrels of heavy fuel which escaped from storage tank when flying section of boiler damaged nozzle on tank. **Oil was ignited by hot bricks** from boiler superstructure.

Shell Petroleum, Ltd., and affiliated Showa Oil, Ltd., **will purchase 25 percent interest in new petrochemical plant to be built in Tokyo by Mitsubishi Yuka.** In turn, Mitsubishi will purchase 25 percent interest in Showa's Yokkaichi refinery now under construction.

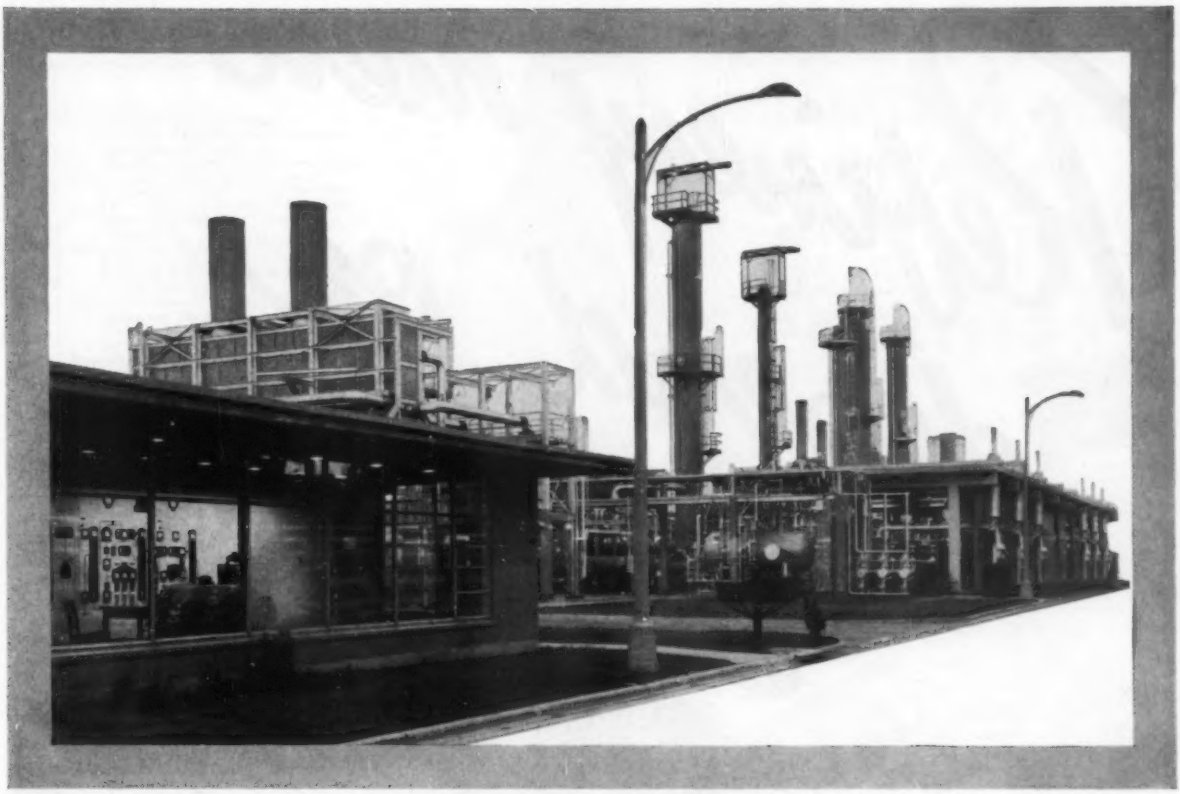
Esso Standard will start **using aluminum cans for motor fuel. System for reclaiming cans after use has been devised** to produce differential betwen aluminum and conventional tin-plated steel. Special can-crushing device permits service station operators to take advantage of aluminum's high scrap value.

Justice Department has quietly launched **investigation of Arabian American Oil Co.** to determine whether joint ownership and operating policies have resulted **"in unreasonably restraining the foreign commerce of the U. S. in violation of the antitrust laws."**

AEC and Phillips Petroleum have signed contract for sale of uranium concentrates to the Commission. Contract will result in construction and operation by Phillips of a **new 1725 ton-per-day uranium processing mill** in McKinley County, N. M.

A changeover from spark ignition engines to compression ignition engines for coming Army vehicles has been recommended by U. S. Army Board. Adoption would mean one less giant market for gasoline.

Average American family **spent $154 for gasoline and motor oil** in 1956 . . . Turkish Petroleum Co. is trying **to make deal with another oil company** to provide it with more foreign exchange . . . report on **1956 lube oil and grease consumption by state is under way by API**—report will be first since 1951 . . . Esso Research and Engineering has **opened a new office in The Hague, Netherlands** . . . Toa Oil Co., Japan, is producing enough high-octane gasoline in its new refinery **to meet the entire domestic Japanese demand.**



Electronic Control SAVES THOUSANDS OF DOLLARS even before start-up

Here is how: The installation of 'American-Microsen' Electronic Controls eliminated the need for a new control house when a new platformer unit was erected at the Pontiac Refining Corporation in Corpus Christi, Texas.

The existing control house (shown above) is far from the site of the new unit. Transmission distances up to 800 feet were involved—distances too great for conventional process instrumentation. But 'American-Microsen' Electronic Instruments are completely unaffected by distances up to 30 miles. Accurate dc signals are transmitted over simple 2-wire circuits with split-second speed. Consequently, Pontiac found it both practicable and economical to install the new platformer instrument panel right in the existing control house.

In addition, transistors, printed circuits and miniaturized components provide the ultimate in reliability, service life and space-saving simplicity. These are but a few of many reasons why 'American-Microsen' – the all-electronic system that uses only three units – is widely preferred for measurement, transmission and control. Write for literature and ask that a sales engineer from our nearby district office call and explain fully. No obligation, of course.

MANNING, MAXWELL & MOORE, INC.

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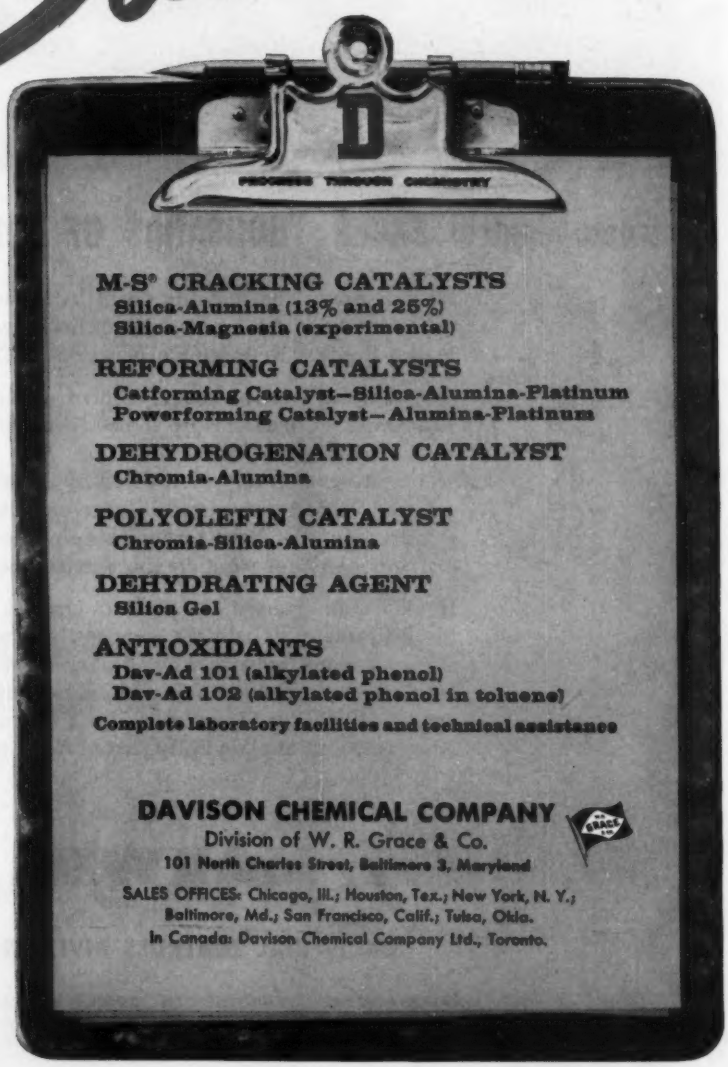
INDUSTRIAL CONTROLS DIVISION • STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL

For more data on advertised products, use Readers' Service Cards, last page.

Refinery men depend on Davison for...



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MEETINGS CALENDAR

OCT.	
13–19	Oil Progress Week.
16–18	American Society for Quality Control, New England Sections, 11th Annual Conference, Stratfield Hotel, Bridgeport, Conn.
18	American Institute of Chemical Engineers, South Texas Section, 12th Annual Technical Meeting, Moody Convention Center, Galveston.
22–24	National Association of Corrosion Engineers, Seventh Annual Western Regional Conference, U.S. Grant Hotel, San Diego.
24–25	Western Petroleum Refiners Assn., Regional Technical-Industrial Relations Meeting, Rufus Garrett Hotel, El Dorado, Ark.
24–25	Fourth Annual Computer Applications Symposium, Sponsored by Armour Research Foundation, Hotel Sherman, Chicago.
25	Natural Gasoline Association of America, Southern Regional, Washington-Youree Hotel and Captain Shreve Hotel, Shreveport, La.
27–29	Independent Petroleum Association of America, Annual Membership Meeting, Statler-Hilton Hotel, Dallas, Texas.
28–29	Annual Meeting, National Lubricating Grease Institute, Edgewater Beach Hotel, Chicago.
28–31	American Nuclear Society, Second Winter Meeting, Henry Hudson Hotel, New York
NOV.	
6– 8	Society of Automotive Engineers, National Fuels and Lubricants Meeting, Hotel Statler, Cleveland.
7– 8	Society of Automotive Engineers, National Fuels and Lubricants Meeting, Statler Hotel, Cleveland.
7– 9	Society of Rheology, Annual Meeting, Princeton, New Jersey.
11–14	American Petroleum Institute 37th Annual Meeting, Conrad Hilton and Palmer House, Chicago.
12–14	National Association of Corrosion Engineers, Northeast Region Fall Meeting, Penn-Sheraton Hotel, Pittsburgh.
13–14	Air Pollution Conference, Armour Research Foundation and Midwest Air Pollution Prevention Association, Chicago.
13–16	National Association of Corrosion Engineers, Miami Section, Key Biscayne Hotel, Key Biscayne, Fla.
22	Natural Gasoline Association of America, Panhandle Plains Regional Meeting, Herring Hotel, Amarillo.
DEC.	
1– 6	American Society of Mechanical Engineers Annual Meeting Statler Hotel, New York.
2	American Society of Mechanical Engineers, Annual Meeting, Hotel Statler, New York.
8–11	American Institute of Chemical Engineers Annual Meeting Conrad Hilton Hotel, Chicago.
1958 FEB.	
3– 4	Instrument Society of America National Conference on Progress and Trends in Chemical and Petroleum Instrumentation, Wilmington, Delaware.
10–14	American Society for Testing Materials, Committee Week, Hotel Statler, St. Louis, Mo.

Use Readers' Service Postcard for More Information on Advertised Products

JOHN CRANE'S line of Chemlon Packing offers an unlimited selection of types, shapes and sizes for practically every service requirement:

. . . . . types best suited for valves and automatic regulators.

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Here in one bulletin is illustrated and described industry's most complete line of chemically inert packings. You'll save time, trouble and expense on fluid or gas handling problems by requesting Bulletin P-325.

Crane Packing Company, 6420 Oakton Street, Morton Grove, Illinois (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

Reviewing New Books . . .

"A Guide to the Literature of Chemistry"

No chemist can possibly know all of chemistry, but he can know how and where to look for chemical information. This book is an effective key to the vast chemical literature. It is the second edition, and is brought up to date to keep pace with the rapid growth of chemical literature in recent years.

The authors analyze various kinds of sources of chemical information; describe and classify important journals, books, and other publications; give ways of keeping up-to-date on various sources; and discuss libraries and indexes in relation to literature searches.

(John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 397 pages, $9.50. For sale by Gulf Publishing Co., P. O. 2608, Houston 1, Texas, U.S.A.).

"Tentative Methods of Measuring Evaporation Loss from Petroleum Tanks and Transportation Equipment"

This bulletin is designed to unify the methods and practices employed to measure evaporation losses from tanks and transportation equipment. Known as API Bulletin 2512, it was prepared by the Institute's Evaporation Loss Committee, under the chairmanship of J. H. McClintock, of Esso Standard Oil Co., New York.

McClintock said Part I of the bulletin discusses the basic procedures in measuring evaporation losses, and offers general guidance for selecting methods for the determination of losses from tanks and transportation equipment under specific conditions of service. Part II provides detailed descriptions of eight methods.

(American Petroleum Institute, 50 West 50th St., New York 20, N. Y. $2.00).

OTS Sales Up

Scientific organizations and industrial firms last fiscal year purchased 240,240 copies of Government technical research reports through the Office of Technical Services, U. S. Department of Commerce, according to John C. Green, OTS Director. This is an increase of 58,131 copies over the fiscal 1956 total, or approximately a 33 percent increase.

OTS is the agency set up by law to collect reports of research from the Army, Navy, Air Force, Atomic Energy Commission, and other agencies, reproduce them, and sell them to science and industry at the cost of reproduction and handling.

As reports are released to OTS by other agencies, OTS announces their availability through press releases to the business and trade press and through its two monthly publications, "U. S. Government Research Reports," which abstracts about 300 reports each month, and "Technical Reports Newsletter." These subscription publications are handled by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscription to the USGRR is $6 a year, and to "Technical Reports Newsletter" $1 a year.

"Quantitative Organic Analysis"

Several features characterize the volume. The authors give a detailed theoretical treatment of a specific method (oximation of carbonyl compounds), and supply a comprehensive up-to-date discussion of theory and scope of nonaqueous acid-base titrations. The book contains discussions of ion exchange methods in organic analysis, kinetic methods, and principles and examples of spectrophotometric methods, especially ultraviolet and infrared. The authors also give principles and examples of gas chromatography and other separation methods, and cover polarography as applied to organic analysis.

The chapter headings include: details of a method; acid-base titrations in nonaqueous solvents; indirect acid-base methods; oxidative and reductive methods; monometric methods; metal ion complexes; elemental analysis; kinetics in analysis; spectrophotometric methods; separations; physical and polarographic methods; solving new analytical problems; and laboratory procedures.

(John Wiley & Sons, 440 Fourth Ave., New York 16, N. Y., 303 pages, $6.50.)

Applications of X-Ray Analysis

Proceedings of the Sixth Annual Conference on Industrial Applications of X-Ray Analysis held by the Denver Research Institute, University of Denver 7, 8, 9 August 1957 are in the editing phase. The paper-backed volume containing about thirty papers on X-ray diffraction, spectrography, and instrumentation will be available about mid-November.

(Dr. W. M. Mueller, Denver Research Institute, University of Denver, Denver 10, Colorado. $4.50).

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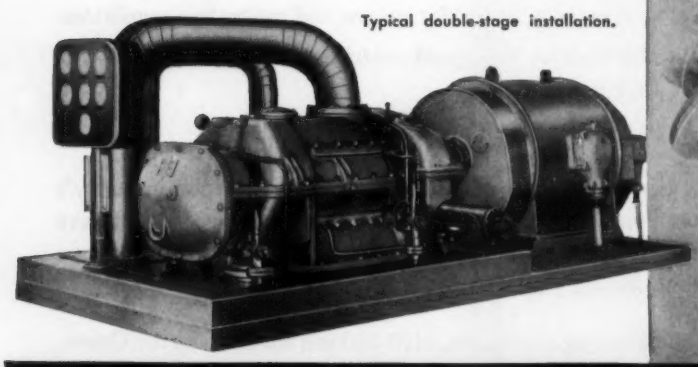
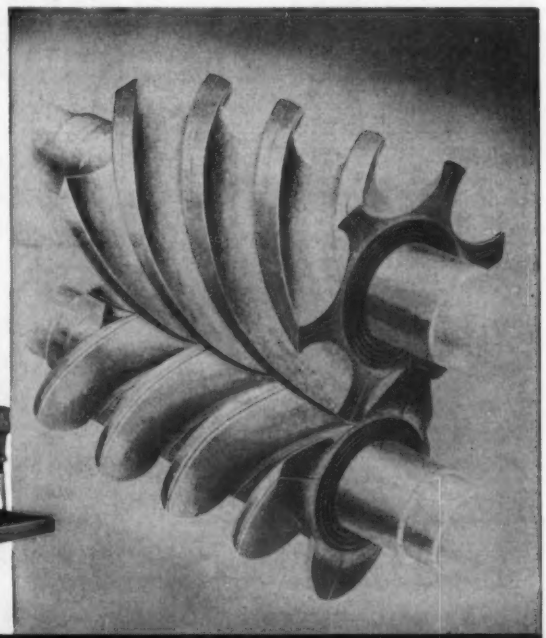
for oil-free handling of air and many other gases. Flow rates range from 350 to 15,900 cfm. Pressures up to 155 psia.

Typical double-stage installation.





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DU PONT *Petroleum Chemicals* NEWS

Number 80 in a Series of Bulletins for the Petroleum Industry

OCTOBER 1957

Du Pont FOA-2 provides advantages to refiners as well as to their customers

"BRIEF CASE" PRESENTATION WELL RECEIVED BY PETROLEUM INDUSTRY AND ITS CUSTOMERS

The "Brief Case for Business" presentation was announced in a NEWS ad last January. Since then 500 kits have been put to use, and they are expected to play an important role in this year's Oil Progress Week. Developed by the DuPont Petroleum Chemicals Division, the "Brief Case" tells an oil industry public relations story in much the same way as the popular "Magic Barrel" has been doing so successfully for nearly five years.

The "Brief Case" presentation, introduced last January 1st, is sponsored by the Oil Information Committee of the API. It tells in a highly dramatic way the importance to the American economy of oil products and of products made from oil. According to OIC estimates, over 1,000 presentations will have been made by November 1 – to club, school and civic groups throughout the country.

Small and low cost

Exhibits in the kit were carefully selected to tell a forceful story. The kit fits compactly into a lightweight, easy-to-carry brief case and costs only $50 complete. If you are not already using the brief case kit, or would like additional kits, any of our DuPont Petroleum Chemicals Division representatives will be glad to help you obtain them.

The versatility of DuPont Fuel Oil Additive No. 2 (FOA-2) provides refiners with processing flexibility as well as sales features for their customers. Here's how . . .

POWER PLANTS can help insure continuous flow of electricity by protecting their fuel oil against sludge formation through the use of DuPont Fuel Oil Additive No. 2.

FOA-2 makes it possible to blend catalytic-cracked stocks with straight-run products and still maintain good storage stability and performance. Because of this, refiners can adjust their inventories of heating and diesel fuels to meet varying seasonal demands. And the storage stability of a catalytic-cracked stock by itself can be increased by the addition of FOA-2.

The additive also helps to upgrade stocks to increase the yield of domestic heating oils, and release straight-run stocks for charging stock.

Protects wide range of products

The stabilizing and dispersant action of DuPont FOA-2 is highly effective across the whole range of distillate fuel oils. This means that the same additive that retards and disperses sludge formations in home heating oils can be used to help prevent injector-sticking and filter-clogging in all types of diesel fuel – for truck, tractor, marine, industrial, and railway locomotive engines.

With this extremely broad range of usefulness, many refiners are able to realize substantial savings in their overall manufacturing and distribution operations through the use of this single additive.

Benefits residuals, too

Because of the nature of the product, sludge problems with residual fuels can be particularly troublesome. Many of the problems can be readily solved by periodic treatment of the system with FOA-2. But it's even easier to prevent them and eliminate many costly tank-cleaning operations by simply adding a small amount of FOA-2 to the residual fuel before it goes into the storage tank.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

CONTINUED

FOA-2 Advantages

Many residual fuel users, both large and small, have already found that FOA-2 will keep their fuel storage and supply systems clean and their burners operating smoothly. Thus, substantial savings are made by eliminating costly downtime for cleaning.

For detailed information

To help you benefit fully from FOA-2 in all these applications, we will be glad to send you a comprehensive 24-page book about it.

All the basic information you will need is included in this book—composition and properties, use concentrations, handling and addition methods, performance testing, and a discussion of the benefits of FOA-2 in all its applications.

Many refiners find pre-mixed additives more convenient

A new combination "package" of DuPont Fuel Oil Additive No. 2 premixed with DuPont Metal Deactivator has been offered to refiners during recent months.

We've heard many favorable comments on this new combination from refiners who have tried it. It has proved a convenience to be able to add a single additive with combined properties that guard against practically all the major chemical causes of heating oil and diesel fuel troubles, specifically sludge and gel accumulations.

The new combination is available to you in drums in two different concentrations . . . FOA-208 – 92% FOA-2, 8% DMD; and FOA-212 – 88% FOA-2 and 12% DMD.

You ought to know . . .

JOHN D. ROGERS is supervisor of the jet and aviation fuels research group at the DuPont Petroleum Laboratory, Carney's Point, New Jersey. In this capacity he serves as an aircraft engineering consultant, working closely with the engine manufacturers and Navy and Air Force test centers on evaluation of fuel performance in the latest aircraft. And his staff at the laboratory analyzes trends in military requirements and related commercial developments to help refiners meet present and future demands for aviation petroleum products.

His broad experience has ideally equipped him to provide refiners with competent aid in these fields.

He joined the DuPont Company in 1951 as a senior engineer at the Petroleum Laboratory. He did engine and combustion research on fuels, and worked with refiners on automotive performance studies until 1954. Before coming to DuPont, he did development work on rocket and jet aviation fuels for a major oil company. During World War II, he was with an aeronautical corporation as combustion analyst and design engineer on B-29 engines.

Mr. Rogers received his B.S. degree in mechanical engineering at the University of Delaware. Later he was an instructor at Yale University, specializing in internal combustion engines. He has also a master's degree from Stevens Institute of Technology, and did advanced study of thermodynamics and fluid mechanics at the University of California in Berkeley.

He is a member of the Institute of Aeronautical Sciences, American Rocket Society and the Society of Automotive Engineers. He is active on the Aviation Fuels Technical Committee of the ASTM and the Aviation Fuels Division of the Coordinating Research Council.

LITERATURE AVAILABLE

Here is a partial listing of the many bulletins, reports, booklets, technical papers, and other aids available to you through any of the DuPont Petroleum Chemicals Division offices:

DuPont FOA-2—A comprehensive 24-page book containing all the basic information you will need to have about DuPont Fuel Oil Additive No. 2 for its application in heating, diesel and residual fuels. Fully illustrated with photographs, charts and diagrams A-4966

New DuPont Dry-dye Eduction Probe and No-dust Drumhead—A folder describing and illustrating the revolutionary new dry-dye eduction devices, which make gasoline dyeing a cleaner, faster, and more efficient operation A-2903

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OVER

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A-5245

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What's Happening . . .

. . . *Among Men* in the Industry

A. Voorhies, Jr., Laboratories' director for Esso Research Laboratories, Baton Rouge, has announced **Drs. C. L. Aldridge, Leo Broussard** and **H. M. Tenney** as the new associates in the "Ladder of Technical Staff Progression" recently adopted for advancement and recognition of professional personnel whose primary interests and talents are along technical lines.

Previously, **Dr. Clark Adams** was named "research associate" and **Kenneth Draeger** "engineering associate" in the plan also in use by Esso Research and Engineering Co., Linden, N. J.

Robert J. Carter, district manager of Stone & Webster Engineering Corp., Houston, has been named a special assistant to the managing director of E. B. Badger & Sons Ltd., London, a subsidiary of Stone & Webster in Great Britain. In 1949 and 1950 Carter was associated in the process and design engineering for the British Petroleum Chemicals project at Grangemouth, Scotland.

Born in St. Louis, Mo., in 1900, Carter graduated from Washington University in St. Louis with a B.S. degree in mechanical engineering in 1924.

He joined Stone & Webster Engineering Corp. in 1939 as an engineer in Boston and worked on petroleum, chemical and gas construction projects in the United States.

On his return from Britain in 1950, Carter was named district manager in Houston.

John S. Wintringham has been named to the newly created position of senior research advisor at the Ethyl Corp. research laboratories in Detroit. Wintringham will be responsible for technical coordination and liaison with the petroleum industry.

Wintringham

In his new capacity, Wintringham assumes many of the former responsibilities of **J. B. MacCauley,** who has resigned to serve, in Washington, as deputy assistant secretary of defense for research and engineering.

Wintringham joined Ethyl in 1930 following graduation from Harvard University and has held key supervisory and engineering positions in the company's research organization.

Stanley L. Krugman has been appointed vice-president of Jacobs Engineering Co., Pasadena, Calif. Krugman, formerly chief engineer is in charge of process and plant design for the chemical and petrochemical industries.

Texaco's Eastman, Eischens To Receive 1958 ACS Awards

Robert P. Eischens

duBois Eastman

For the first time in the history of its annual awards, the American Chemical Society has honored two scientists in a single industrial research organization. The ACS Award in Industrial and Engineering Chemistry went to **duBois Eastman,** director of Texaco's Montebello, Calif., Laboratories.

The Precision Scientific Co. award in Petroleum Chemistry went to **Robert P. Eischens** of the Physical Research department, Texaco Research Center, Beacon, N. Y.

Presentation of the awards will be made at the 1958 Spring national meeting of the ACS in San Francisco.

Eastman, 51, has been responsible for the development of a new method for manufacturing hydrogen which has found worldwide application. The Texaco Synthesis Gas Generation process, has been, or is being, installed under license in 25 chemicals plants in North and South America, Europe, and Asia.

Eastman was chairman of the Technical Advisory committee of the Neches Butane Products Co. during World War II. This emergency enterprise built and operated for the government one of the country's key synthetic rubber plants near Port Neches, Texas.

Since his wartime assignment, Eastman has headed Texaco's synthesis processes research at Montebello, Calif. He has been with the company since he graduated from the University of California in 1928. He is a native of Berkeley, Calif.

Dr. Eischens, 37, has published new basic information on an old scientific mystery—catalysis. This natural phenomenon has long been known, and used. But science hasn't discovered exactly how it works.

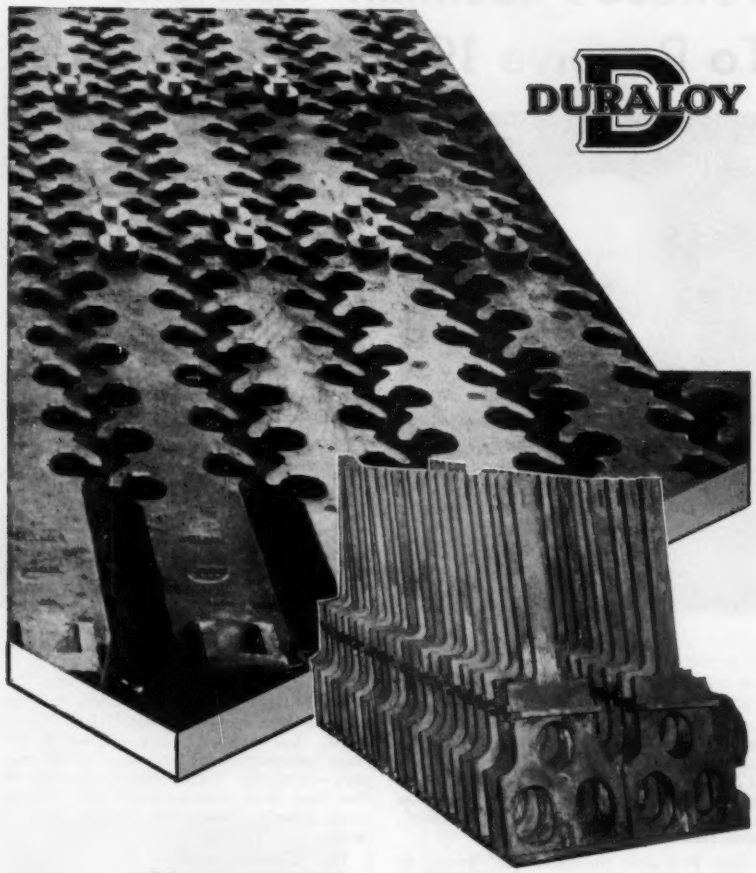
Dr. Eischens' studies have revealed some aspects of the behaviour of chemical molecules during catalysis, and his work has been widely recognized. In 1956 a leading German scientific group, the Bunsen Society, invited him to address one of its sessions.

Dr. Eischens started his catalysis research as a graduate student at Northwestern University where he was awarded a Ph.D. degree in chemistry in 1948. He has been with Texaco since that time. He is a native of Glenmore Township, N. D.

T. J. Loughridge has been promoted to senior supervising engineer, **G. H. Ferguson, Jr.,** to supervising engineer, and **R. E. Burns,** to senior mechanical engineer in engineering division, and **R. S. Manne,** to senior research chemical engineer in Research and Development division at Humble Oil & Refining Co.'s Baytown, Texas, refinery.

Loughridge is in charge of the electrical engineering and general drafting sec-

CORROSION RESISTANT
HEAT RESISTANT
Tube Supports



You can't buy Better Tube Supports ... DURALOY Tube Supports are alloyed to meet individual corrosion and heat requirements. They are alloyed by experienced metallurgists and melted and cast by experienced high-alloy foundrymen, both groups with experience going back some thirty years. Castings are carefully tested in our own laboratories which are completely equipped for metallurgical, chemical and physical testing.

Many refineries have been DURALOY customers for years. Many refineries insist upon DURALOY castings. Whether it's straight production or engineering plus production, we are equipped to do the job. For more information, send for Bulletin No. 3150-G.

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Men in the Industry ...

tion in Engineering Design department, and Ferguson is responsible for a group of engineers and inspectors who provide engineering guidance and inspection services at the Butyl and Butadiene plants. Burns handles engineering problems relating to the maintenance of refinery storage facilities and the use and application of protective coatings. Manne is engaged in research on improving motor fuels.

Loughridge and Ferguson hold B.S. degrees from Texas A & M in electrical and mechanical engineering, respectively; Burns a B.S. degree in mechanical engineering from Texas University; and Manne, a B.S. degree from Yale and an M.S. degree from Vanderbilt, in chemical engineering.

J. D. Barrington has resigned as president and managing director of Polymer Corp., Ltd., and **E. R. Rowzee** has succeeded him.

Barrington has resigned in order to accept the position of president and managing director of Ventures Ltd., but he will continue to be a member of the board of directors of Polymer.

Rowzee has been vice president and manager of Polymer since 1951. A graduate of MIT in chemical engineering, he has been associated with Polymer since 1942. He was one of the pioneers in the development of synthetic rubber on this continent. He moved to Canada on loan to Polymer and has since become a Canadian citizen. It was also announced that **L. D. Dougan** has been appointed vice president—operations. Dougan has been with Polymer since September, 1944. Since that time he has been director of production, assistant manager and since 1951, has been plant manager with direct responsibility for production, industrial relations, engineering and the technical divisions. He is a graduate of the University of Toronto with a degree in chemical engineering.

R. C. Faulkner, general manager of the Gulf Oil Co.'s Port Arthur, Texas, refinery will be transferred to the general office in Pittsburgh to head the mechanical design and construction activity of the Pittsburgh Engineering division of the Manufacturing department.

It was also announced that **J. O. Timms,** general manager of the Philadelphia refinery, will be transferred to Port Arthur as general manager, succeeding Faulkner. **T. A. Dietz,** manager—engineering at the Philadelphia refinery, will be promoted to general manager, succeeding Timms. **D. E. Hart,** general manager of the company's Toledo refinery, will be transferred to the Port Arthur refinery as manager—operations. **A. A. Niehenke,** general manager of the Cincinnati refinery, will be transferred to the Toledo refinery as general manager, succeeding Hart. **T. F. Hogan,** manager—operations at Port Arthur, will be transferred to the Cincinnati refinery as general manager, succeeding Niehenke. **H. M. Vaughan,** manager—engineering at Port Arthur, will be transferred to the Philadelphia refinery in the same capacity, succeeding Dietz.

Also **R. S. Justiss,** director—mechanical design, Pittsburgh Engineering division of the Manufacturing department, will be transferred to Port Arthur as manager—engineering, succeeding Vaughan. **J. N. Miller,** director—process engineering at

For more data on advertised products, use Readers' Service Cards, last page.

Modern refinery processes use

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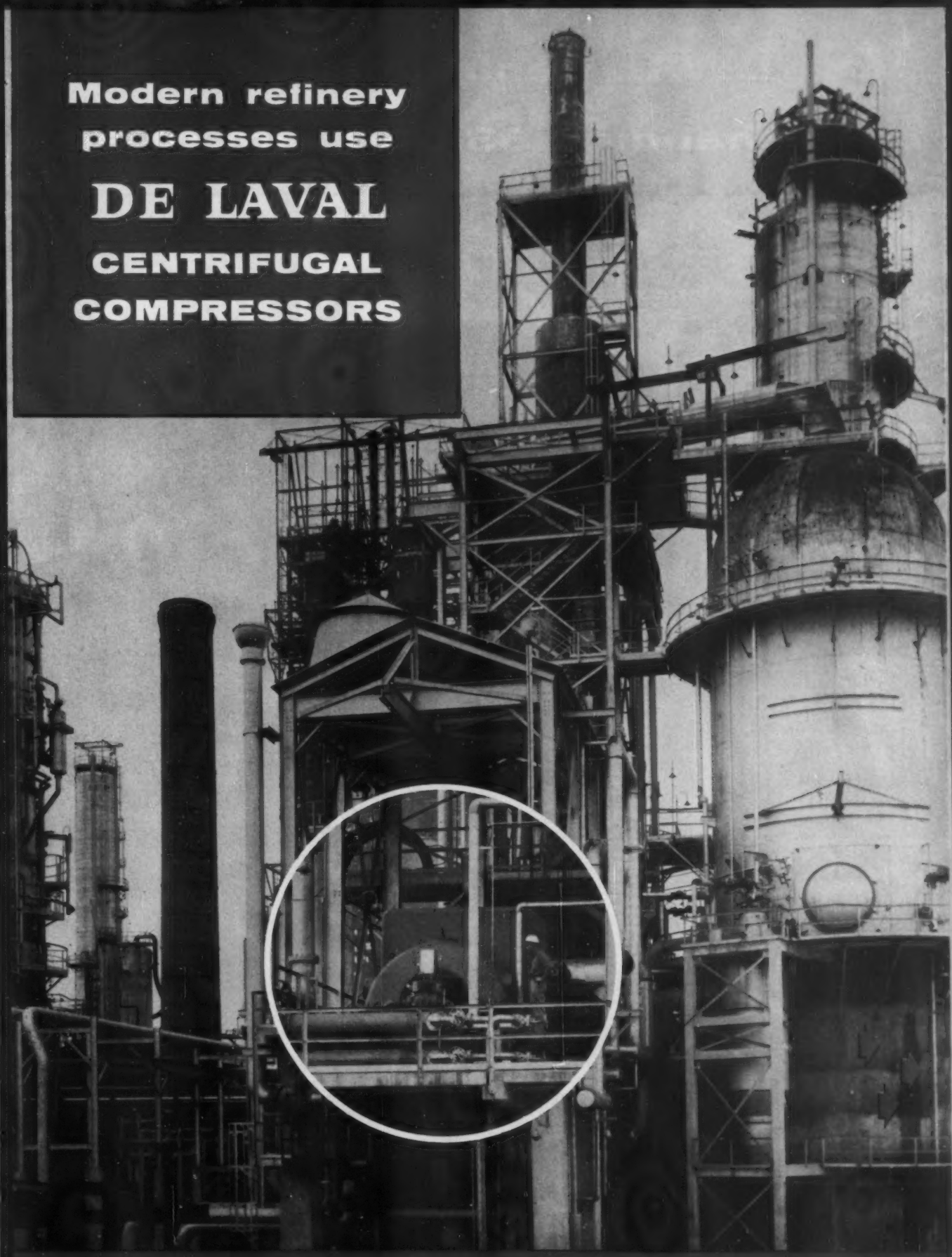
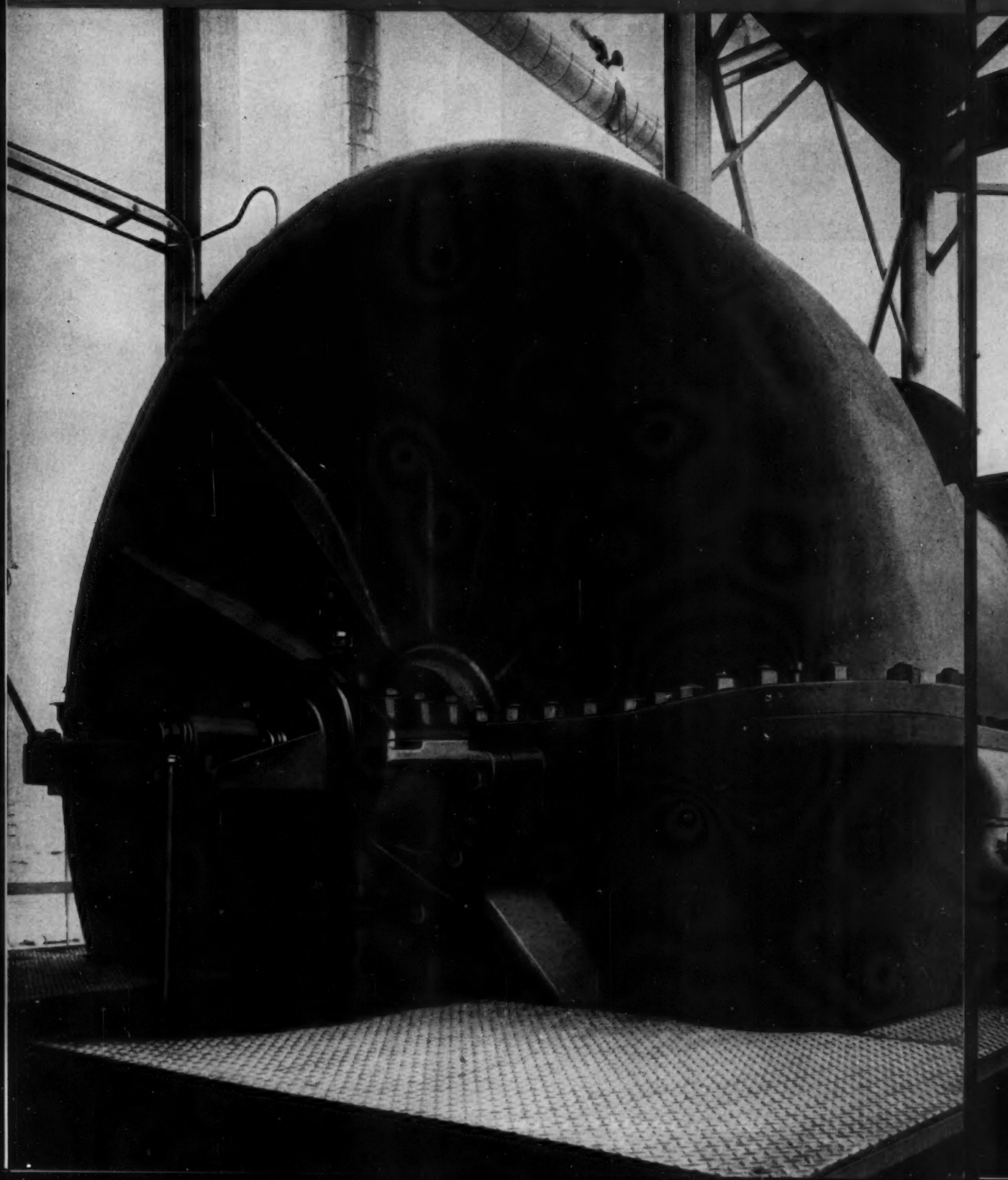
CENTRIFUGAL COMPRESSORS



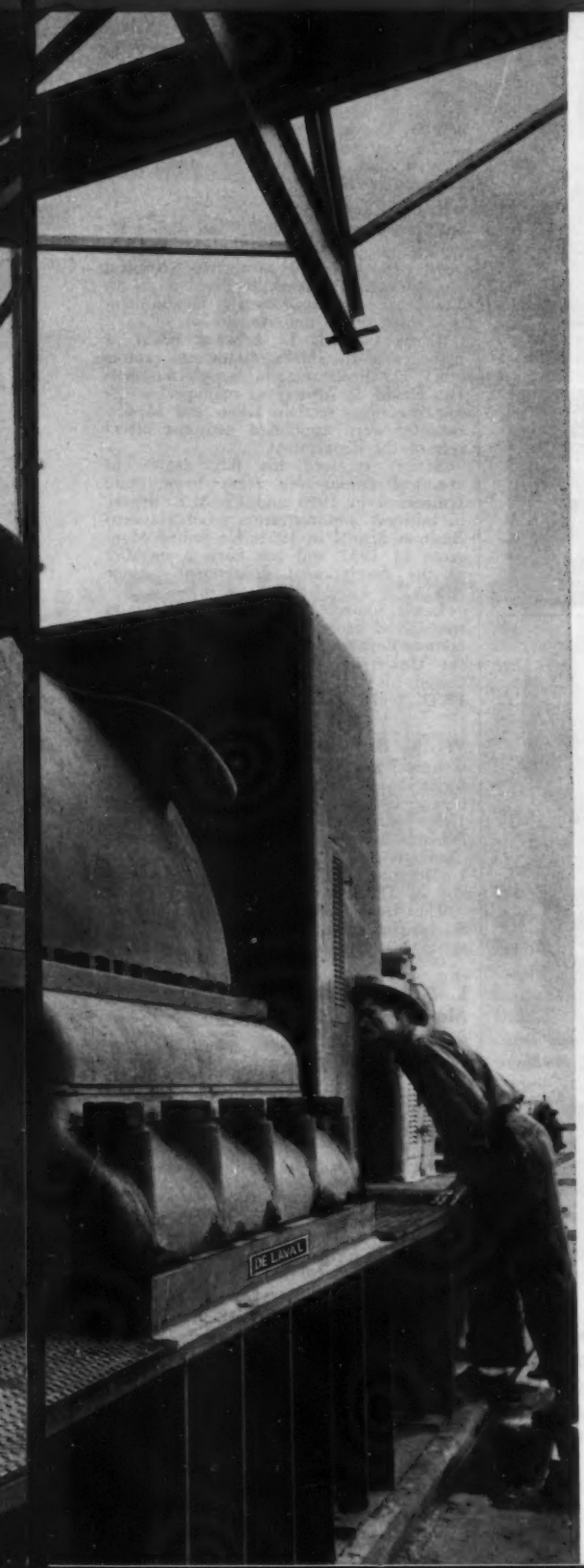
DE LAVAL STEAM TURBINE COMPANY · TRENTON 2, NEW JERSEY

DE LAVAL Centrifugal Compresso

handles 83,000 cfm of air a A



Ashland Oil & Refining Company



This De Laval turbine-driven main air blower handles 83,000 cfm at 47.4 psia in the UOP Fluid Catalytic Cracking Unit at the Ashland Oil & Refining Company plant in Ashland, Kentucky. Built by Procon, Incorporated, the cat cracking unit processes 22,000 barrels per day.

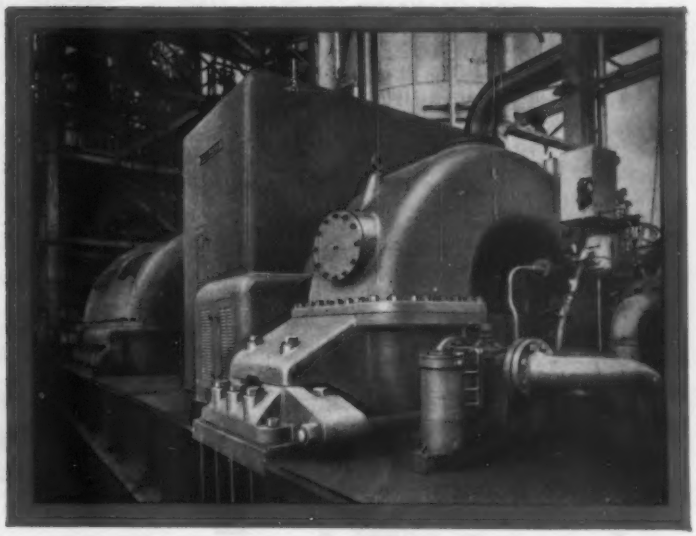
The compressor is driven by a 10,200 hp De Laval extraction turbine designed for 440 psi, operating at 700F with 1½" hg. vacuum. It extracts 150,000 pounds per hour at 155 psig.

As proof of the dependability of De Laval design and manufacture, another De Laval turbine-driven main air blower, which will deliver 110,000 cfm, is on order for a new UOP Fluid Catalytic Cracking Unit. The processing unit is currently being constructed for a leading Midwest refinery.

Available for every refinery process

Whether you need to handle light or heavy gases at high or low pressures in catalytic cracking, reforming, alkylation, coking or any similar service, it pays to look to De Laval. Rugged De Laval centrifugal compressors perform dependably in heavy-duty continuous operation. De Laval has more than 40 years of experience in solving gas compression problems.

Send for De Laval Bulletin 0504.



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Centrifugal Compressors

DE LAVAL STEAM TURBINE COMPANY

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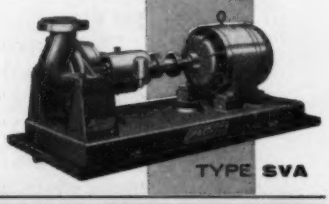
DL 389

Whatever your Pumping Problems–

PACIFIC®

PROCESS PUMPS

give you the right answers!



TYPE SVA

RATINGS	TYPE SVA	TYPE SVS	TYPE SVC	TYPE RVC
Capacity — in GPM	15 to 1300	15 to 1000	25 to 3200	50 to 600
Pressure — in PSIG	To 600	To 600	To 600	To 600
Head — in feet	To 600	To 600	To 600	To 900
Temperature — °F	To 300	To 300	To 850	To 850
Number of stages	One	One	One	Two

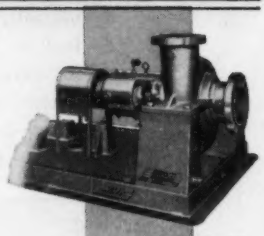
DESIGN
PACIFIC'S skillful mechanical and hydraulic design.

MATERIALS
Top-quality materials of construction for the service conditions involved.

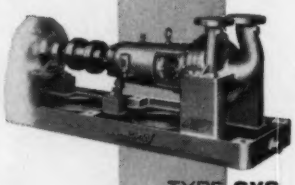
WORKMANSHIP
Precision workmanship by PACIFIC'S skilled craftsmen.

Included in the characteristics of all PACIFIC process pumps are the elements of unequalled quality that have made them preferred in petroleum refineries, natural gasoline plants and petrochemical installations throughout the world. For the pumping requirements of your process plant–The name to remember is PACIFIC.

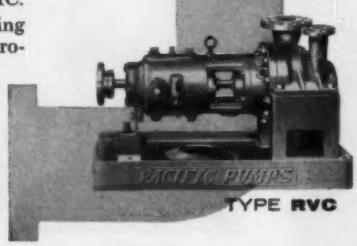
Write for Bulletins, describing and illustrating PACIFIC process pumps.



TYPE SVC



TYPE SVS



TYPE RVC

PACIFIC®

PACIFIC PUMPS INC.

HUNTINGTON PARK, CALIFORNIA

Offices in All Principal Cities

CP15

Men in the Industry . . .

Port Arthur, will be assigned to the Process Design division in Pittsburgh, and **B. A. Kreiter** of the Process Design division in Pittsburgh, will be transferred to Port Arthur as director—process engineering, succeeding Miller.

John F. Brennan and **Robert T. Lawson,** formerly chief engineers of the New York and San Francisco offices of Dames & Moore, respectively, and **Warren D. Curtis,** former engineer-in-charge of the Salt Lake City office of Dames & Moore have been recently admitted as partners in the firm.

Dr. Norman J. Lewis and **James H. Senger,** project specialists in the development department of Monsanto Chemical Co.'s Organic Chemicals division at St. Louis, have been promoted to section managerships in the department.

Lewis succeeds **L. Edward Klein** as manager of the intermediates and exploratory chemicals section. Senger succeeds **Dr. David T. Mowry** as manager of the fine chemicals section. Klein and Mowry recently were appointed assistant directors of the department.

Senger received his B.S. degree in chemical engineering from Iowa State University in 1948 and his M.S. degree in business administration from Harvard Business School in 1951. He joined Monsanto in 1951 and has been a member of the development department since 1953.

Lewis joined Monsanto in 1951 and transferred from research to the development department in 1955. He attended the University of Florida where he received his B.S. degree in 1947 and his Ph.D. degree in 1951, both in chemistry.

W. E. Blankenstein has joined the technical staff of Esso Research Laboratories, Baton Rouge, La. Other new members include R. J. Fox, D. E. Gensheimer, J. A. Johnson, H. E. Merrill, R. L. Ray, Donald Schwartz, and H. E. Stanley, chemists; R. G. Beecher, E. N. Cart, R. L. Dobson, G. D. Fisher, W. J. Hatcher, and K. H. Moritz, chemical engineers.

The Laboratories also has announced **R. L. Hurley** as its first full-time public relations staffman.

L. Edward Klein and **Dr. David T. Mowry,** have been appointed assistant directors in the development department of Monsanto Chemical Co.'s Organic Chemicals division in St. Louis. Both Klein and Mowry move up from section managerships within the department. Klein has been in charge of development work on intermediates and exploratory chemicals since 1952 while Mowry has been responsible for fine chemicals development since 1955.

Klein joined the department as a project specialist after receiving an M.S. degree in chemical engineering from California Institute of Technology in 1947. He received his B.S. degree from Lehigh University in 1942 and served one year with Atlas Powder Co. prior to three years of military service.

Mowry joined Monsanto's central research laboratory at Dayton, Ohio, in 1941 and became a research group leader in 1944. He transferred to the former

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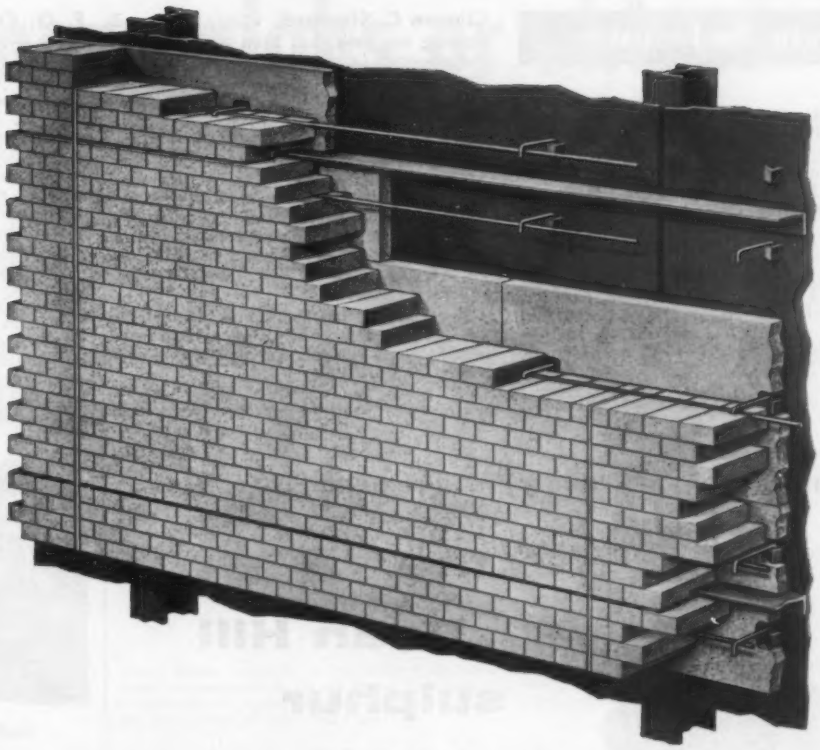


B&W Insulating Firebrick sectionally supported wall construction, horizontal rod-type anchoring

Can this construction cut your costs?

Simplified design and lower material costs in initial construction, ease of installation and maintenance, reduced downtime and economy of operation—these are the benefits of this *lightweight* insulating firebrick construction.

Here's what lightweight means. Compared with dense fireclay refractory materials that weigh from 125 to 140 lb per cu ft, lightweight insulating firebrick weigh approximately 26 lb per cu ft for B&W's 2000 degree brick. This difference provides two major advantages: (1) mechanical, which largely affects design and construction, and (2) thermal, which saves in maintenance, downtime and operation.

Savings in design and construction

The use of lightweight IFB simplifies engineering requirements and reduces costs. A minimum of detailing is needed, since the design is engineered around one standard shape — a feature of B&W IFB constructions.

Material requirements are simplified, too. B&W IFB can be tailor-cut, drilled or shaped as necessary, eliminating the need for costly special fired shapes, and the delays in obtaining them. Typical sections, such as burner openings, observation ports and tube supports, can be cut and shaped on the job in minutes, using ordinary woodworking tools.

Substantial savings are possible in structural steel, since insulating firebrick roof and wall constructions are lighter. In locations with soil of poor load bearing capacities, this lightweight may also result in reduced foundation costs.

These savings, coupled with B&W's engineering and service facilities available during the design phase, mean lower initial costs.

Savings in maintenance, downtime and operation

Lightweight IFB offer a major thermal benefit—they store and conduct less heat. Heavy refractories retain heat; in the event of forced shutdown, they can cause burn-out of expensive alloy tubes, where used. The low quantity of heat stored by B&W IFB can be quickly dissipated, thus protecting these expensive tubes.

Further, this low heat storage permits faster heating and cooling. This means quicker access to the furnace in the event of emergency shutdown. Your maintenance crew can get in the furnace sooner and get it back on stream faster.

Supplied from nearby warehouses

With the use of simplified IFB constructions, refractory repairs can be quickly and easily accomplished with standard shapes from a nearby warehouse. This eliminates costly delays in obtaining special shapes.

Anchoring devices, too, are simplified. Since there are no expensive special castings in B&W IFB constructions, carbon steel or low alloy rods can be used. These are generally available from any local steel warehouse.

Increased efficiency

Generally, the lighter a firebrick the better an insulator it is. Since B&W IFB are the lightest insulating firebrick made, they are the most efficient insulators. Per inch of thickness, B&W IFB provide more insulation than any other refractory material. The result is that for walls of equivalent thickness less heat is lost with B&W IFB. Casing temperatures are lower, thus improving working conditions. This means increased efficiency and reduced operating costs.

R 238

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

For more data on advertised products, use Readers' Service Cards, last page.

Men in the Industry . . .

Phosphate division in 1952 as manager of chemical development and moved to the Organic Chemicals division's development department in 1954. Born and raised in Korea, he received a Ph.D. degree in chemistry from Ohio State University in 1941.

Dr. W. E. Hanford, formerly vice president of The M. W. Kellogg Co., has been appointed assistant to the president for research and development of Olin Mathieson Chemical Corp. Hanford will be located in New York.

Clinton C. Steward, widely known oil refining engineer, has been named assistant manager in charge of engineering and process of the Petro-Chemical division of Holmes & Narver, Inc., Ls Angeles engineers and constructors.

Before joining Holmes & Narver, Steward served as chief engineer of The Ralph M. Parsons Co. Earlier he served in a similar capacity for the Bechtel Corp. Steward's previous background includes five years as refinery engineer for International Petroleum Corp., in Peru and several years as refinery engineer for Foster-Wheeler Corp.

A graduate of Valparaiso University with a B.S. degree in chemical engineering, Steward is a registered chemical engineer in California.

meets every requirement

the Dean Hill sulphur pump

low cost operation

heavy duty construction

reliability

The Dean Hill vertical, molten sulphur pump equipped with a DH vertical steam turbine drive. (Available also with vertical hollow or solid shaft motor drive.)

Like all Dean Hill products, this sulphur pump incorporates all of the features to give you years of trouble-free operation. Complete steam-jacketed line shaft and discharge column assures free flow at all times. Actual liquid sulphur lubricates bearings and shaft damping bushings. The Dean Hill sulphur pump is a compact, self-contained, rigid, smooth-running mechanism capable of superior service at all times. For complete information write today, without obligation.

DEAN DH HILL PUMP COMPANY

Pump and Turbine Engineers Since 1893

Indianapolis 7, Indiana

SALES OFFICES IN PRINCIPAL CITIES.

E. Q. Camp and **J. C. Schiller** have been promoted to assistant division heads in Research and Development division at Humble Oil & Refining Co.'s Baytown, Texas, refinery; **S. R. Bethea, M. R. Morrow, M. A. Mosesman** and **C. E. Zerwekh** have been named section heads in the same division.

Camp is responsible for the sections conducting research on fuels and lubricants, and on corrosion, and air and stream pollution abatement. Schiller is in charge of the sections engaged in research on petrochemicals, and a group of research specialists.

Bethea's section conducts research on lubricants and Morrow's, on gasolines, distillates and solvents. Mosesman's section is engaged in analytical research, and Zerwekh heads the new technical information section, including library, patent coordination and clerical groups.

Peeler

Herget

Winston S. Peeler, has been elected vice president in charge of manufacturing and a member of the board of directors of American Oil Co. Peeler, who succeeds the late **Dr. Harold R. Snow,** had served as general manager of manufacturing since last February when he moved to New York from Texas City. **Walter T. Herget** has been named to succeed Peeler as general manager of manufacturing.

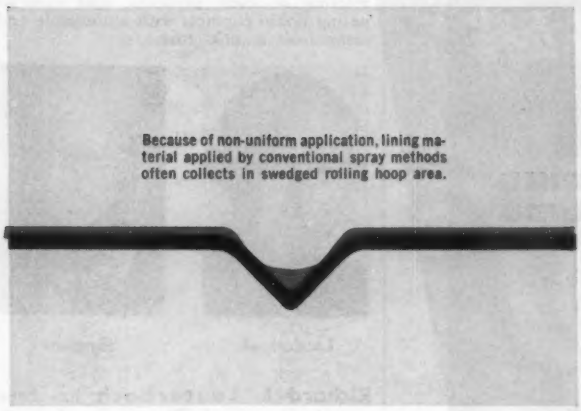
Peeler joined the company in 1934 as a chemical engineer in the research and development department in Texas City. After a series of promotions he became operating superintendent at the company's Texas City refinery in 1952 and was promoted to general superintendent in 1953, a position he held until he moved to New York. He was born in Dallas and graduated from Rice Institute in 1933 with a B.S. degree in chemical engineering.

Herget joined American Oil's research and development department at the Texas City refinery in 1942 and has had experience in technical service, process design and refining economics. In 1947 he became head of a newly-organized chemical department and in 1955 was named general superintendent of the company's new Yorkton, Va., refinery. He was promoted to the position of manager of operations in the manufacturing department in New York in 1956.

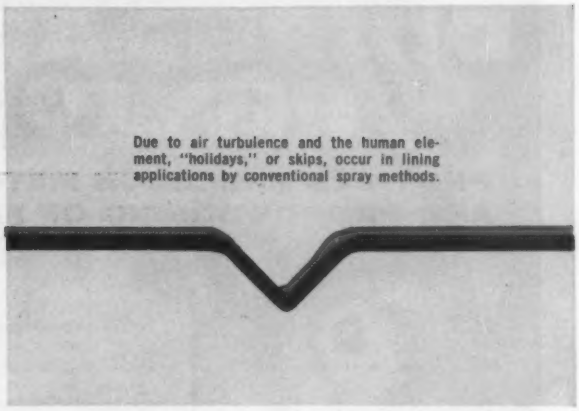
Homer H. Dedo, consultant and section supervisor in the Standard Oil Co. (Ohio) manufacturing department in Cleveland, for the past three years, has been assigned to the newly-created post of automotive consultant, with headquarters in Detroit.

Dedo will undertake technical studies and liaison with automotive manufacturers. His responsibilities will include keeping Sohio's Manufacturing and Marketing departments informed concerning current and future developments and trends in the automotive industry, communicating with

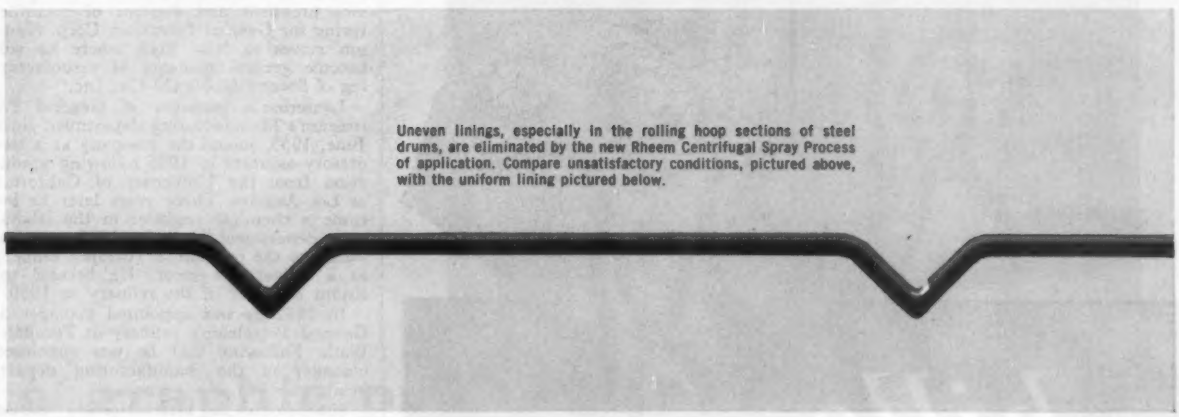
No more globs or skips!



Because of non-uniform application, lining material applied by conventional spray methods often collects in swedged rolling hoop area.

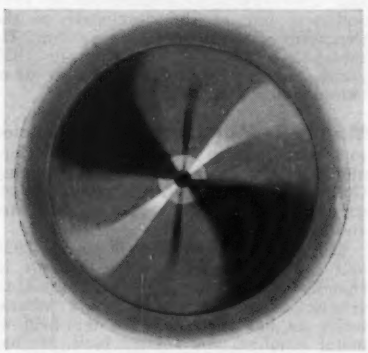


Due to air turbulence and the human element, "holidays," or skips, occur in lining applications by conventional spray methods.



Uneven linings, especially in the rolling hoop sections of steel drums, are eliminated by the new Rheem Centrifugal Spray Process of application. Compare unsatisfactory conditions, pictured above, with the uniform lining pictured below.

New Rheem Centrifugal Spray Process gives you a completely uniform lining, drum after drum after drum!



New Centrifugal Sprayer spins off a continuous curtain of finely atomized lining material at a controlled, uniform rate.

All surface areas of a drum automatically lined by the new Rheem Centrifugal Spray Process are—*and stay*—completely and uniformly coated.

This new, fully automatic process not only eliminates globs and skips but blisters and pinholes as well. And Centrifugal Spraying, teamed with the new Rheem Vertical Baking Process, results in a curing job never before equaled!

Only the new Rheem Centrifugal Spray Process gives you: (1) Uniform lining thickness—controlled to within .1 of a mil. (2) Uniform viscosity of lining materials with lower solvent content. (3) Uniform application. There's no air turbulence because there's no air used in the spray and no drum rotation. Spray always travels the same distance to coat all surfaces. Human element eliminated. (4) Uniform curing—thanks to vertical, 3-stage ovens with controlled air flow and temperatures.

In Rheem Baking Ovens, evenly heated air flows vertically through lined drums for uniform curing.

YOU CAN RELY ON Rheem WORLD'S LARGEST MAKER OF STEEL SHIPPING CONTAINERS

For full details write:
Rheem Manufacturing Company

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NEW DIAPHRAGM PUMP*

PROVIDES PRECISION METERING AND PROPORTIONING OF FLUIDS

Versatile . . .

NEW high pressure range
NEW broad capacity range
NEW wide operating speed range

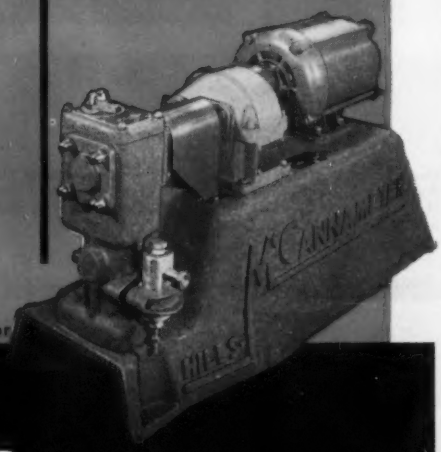
Accurate . . .

NEW precision for small quantities
NEW stepless stroke control

Cuts maintenance costs to a nub

NEW Teflon-faced diaphragm*
NEW packless design
NEW capsulated construction
NEW liquid end free of frictional parts
NEW lifelong lubrication

*Pat. appl. for



hills-mccanna company

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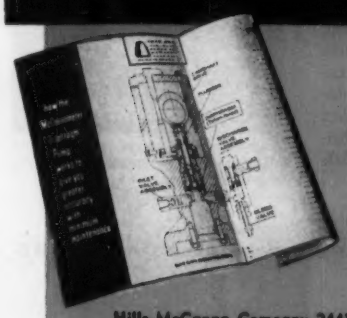


WRITE FOR FREE BOOKLET TO *REALLY* GET ACQUAINTED WITH THIS NEW DEVELOPMENT

Schematic drawing and full description shows you how the new McCannameter Diaphragm Pump works to deliver optimum performance in accuracy, versatility with low maintenance. Write for "A New Concept in Precision Metering and Proportioning of Fluids", booklet #301.

Hills-McCanna Company 2441 West Nelson Street, Chicago 18, Illinois

Men in the Industry . . .

manufacturers concerning Sohio studies relating to their products, and co-ordinating Sohio contacts with automobile and component manufacturers.

Lauterbach

Simpson

Richard E. Lauterbach has been named to succeed **Thomas P. Simpson**, vice president and director of manufacturing for General Petroleum Corp. Simpson moves to New York where he will become general manager of manufacturing of Socony Mobil Oil Co., Inc.

Lauterbach, manager of General Petroleum's Manufacturing department since June, 1953, joined the company as a laboratory assistant in 1936 following graduation from the University of California at Los Angeles. Three years later he became a chemical engineer in the laboratory department, and in 1945 was assigned to the company's Torrance refinery as a refinery engineer. He became assistant manager of the refinery in 1950.

In 1952 he was appointed manager of General Petroleum's refinery at Ferndale, Wash. Following that he was appointed manager of the manufacturing department.

Simpson is an internationally known authority on petroleum research. He joined General Petroleum as a chemical engineer in 1924 and in 1935 was transferred to Socony-Vacuum Oil Co., Inc. (now Socony Mobil) as chief development engineer for the Socony laboratories.

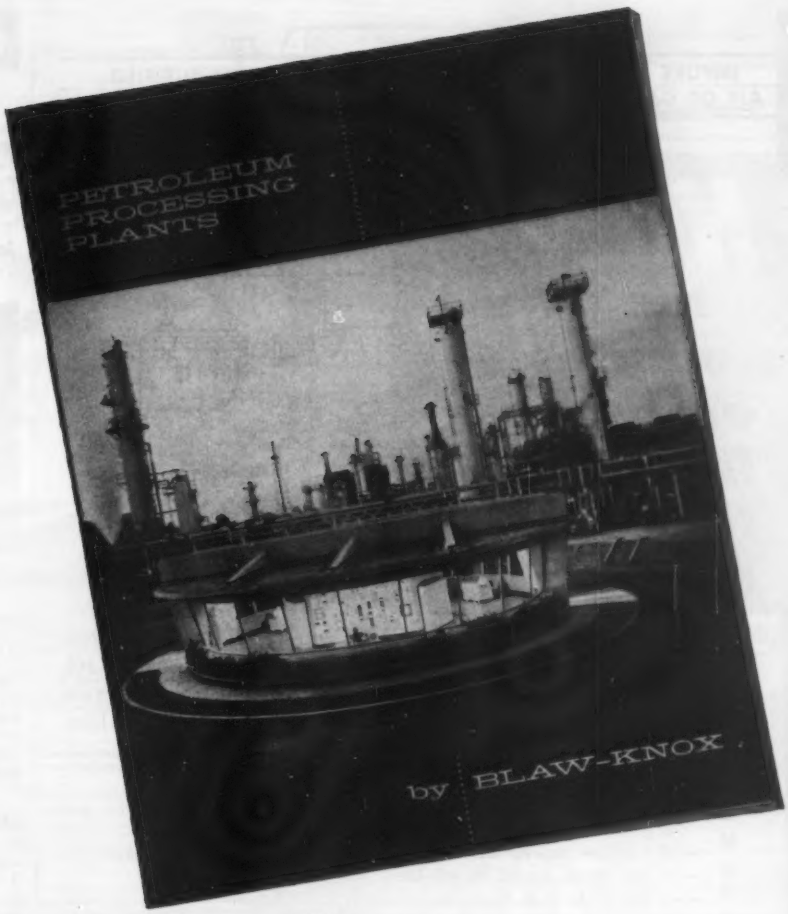
He became director of the Research and Development department in 1947 and was one of the developers of the thermofor catalytic cracking process. He returned to General Petroleum in 1953 and became vice president and director of manufacturing in 1955.

Morris R. Morrow has been promoted to section head in Research and Development division at Humble Oil & Refining Co.'s Baytown refinery. His section is engaged in research on gasolines, distillates and solvents.

Morris received his B.S. degree in 1939 and his M.S. degree in 1940, both in chemical engineering from the Texas University. Since joining Humble's laboratories he has specialized in the field of motor gasolines and related fuels. He has been granted five U.S. patents, and has had three papers published in national journals. He is a member of Society of Automotive Engineers and the AIChE.

Harry F. Poll has joined Ehrhart & Associates, Inc., Engineers and Constructors, Los Angeles and San Francisco, as process development manager. His headquarters will be in Los Angeles.

Formerly, he was process engineering



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highlighting the extent of engineering and construction services available to every phase of petroleum processing.

describing a cross-section of performance, accomplishment and over-all contribution to the industry.

showing how expert contract management can relieve you of the multiplex burdens encountered in completing a project.

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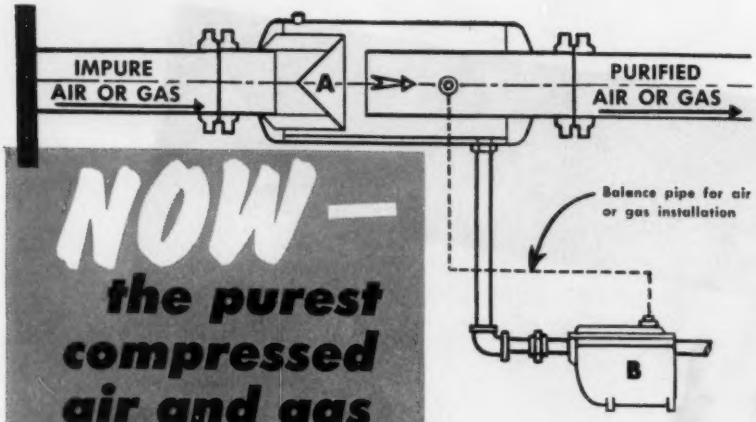
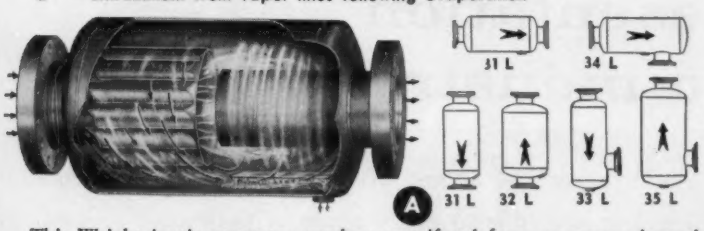


NOW— the purest compressed air and gas is yours with this W-A equipment

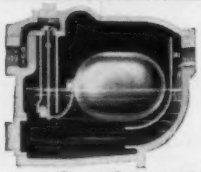
GUARANTEED TO REMOVE 99% OR MORE OF ENTRAINED MOISTURE AND SOLIDS

Where pipe lines carry compressed air and gas, liquids and solids are generally entrained in the gas stream. Wright-Austin 30L Series Separators can be used to remove foreign matter on a wide range of applications. For operating pressures to 5000 PSIG. Line sizes to 24". Here are some typical applications:

REMOVE
—oil and water from compressed air supply lines
—oil and water on compressed air service at outlet of inter-cooler and after-cooler equipment.
—oil, moisture and tar between stages in coke oven gas compressors
—oil and water from CO_2 gas lines
—oil and water from hydro-carbon lines
—entrainment from vapor lines following evaporation



This Wright-Austin separator employs centrifugal force to remove impurities from steam, air or gas flow. The pressure drop is extremely low. Type 31L, as well as other models shown, is light weight, compact and sturdily constructed according to ASME code.

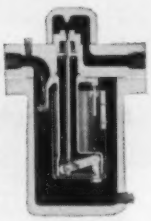


23-AC TRAP (0-125 PSIG)

Separated condensate flows to trap. Drainage is automatic. Particularly adapted where cold, gummy, emulsified cylinder lubricants make ordinary traps inoperative.

B

101-AC TRAP (0-600 PSIG)



Cast steel body, cover and bonnet. Designed for draining condensate where high pressures are involved. Internal mechanism all attached to cover for easy service.

WRIGHT-AUSTIN COMPANY
1894
3245 WIGHT STREET • DETROIT 7, MICH.

WRITE FOR NEW CIRCULAR

Men in the Industry . . .

supervisor for the Union Oil Co. of California, where he contributed to the process development of the Unifining Process. Earlier he was associated with Trojan Powder Co. in high explosives research and production.

James McDonald, assistant manager of Tidewater Oil Co.'s Delaware refinery, has been advanced to the post of administrative manager of manufacturing.

McDonald

With headquarters in San Francisco, McDonald will assist Hyde in planning, developing and coordinating Tidewater's refining activities.

McDonald worked on engineering phases of the new Delaware Refinery during the design and construction period when he was appointed assistant manager. From 1940 to 1953, he was employed at the Tidewater refinery at Bayonne, N. J., rising to become assistant process superintendent. He graduated from Yale in 1937 with a B.S. degree in mechanical engineering and subsequently studied chemical engineering at the Polytechnic Institute of Brooklyn.

Stanley E. Shields has been made a research associate in the pilot plant division of Standard Oil Co. (Indiana), while **Reimer E. Probst** has been appointed to the new post of senior research scientist in the lubricants division of its research department.

Shields has been with the company since 1941 and has been active in development work on new processes in the pilot plant division. He received an M.S. degree in chemical engineering from Syracuse University and did graduate work at Columbia University where he was a Samuel Anthony Goldschmidt Fellow from 1937 to 1939.

Dr. Probst, a native of Germany who became a United States citizen a year after joining the company in 1950, is the first appointee to his position. He is a graduate of Karlsruhe Institute of Technology and the University of Munich and received his Ph.D. degree in physical chemistry from Stuttgart Institute of Technology.

LeRoy B. Fox, manager of the fuel oil division of the gasoline and fuel oil department, Socony Mobil Oil Co., Inc., since January, 1946, has been appointed manager of the asphalt department. He succeeds **George R. Christie,** who joined the company 41 years ago and was manager of the asphalt department for 19 years. Christie will retire soon.

Succeeding Fox is **Leonard S. Marshman,** who had been manager of the crude oil division of the distribution department of Mobil Overseas Oil Co.

Humble Oil & Refining Co. has announced the promotions of **N. K. Brill, G. E. Crist, T. R. Herndon, W. H. Schweitzer, W. R. Smith** and **W. F. Tate** in Engineering division at the Baytown,

For more data on advertised products, use Readers' Service Cards, last page.

... to buy new plants for industries all over the world

IT came from companies in 35 foreign countries—and from firms like yours throughout America. It represents more than a billion dollars in plant investment entrusted to McKee for engineering, construction and related services.

There are sound reasons why world-wide industry comes to McKee when it goes shopping for new plants. First, of course, is McKee's demonstrated ability to do the job. Other factors are McKee's 50 years of experience, international scope, large organization of top-grade engineering talent and an unmatched fund of specialized technical knowledge. But the most important reason is ***McKee builds plants that earn profits.***

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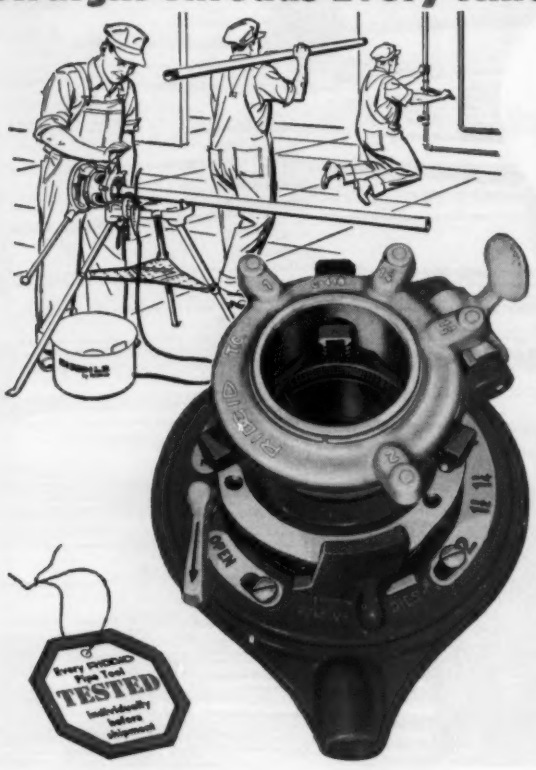
RIDGID

Jam-proof 65R Now Guarantees Straight Threads Every Time



...Revolutionary New TC (True-Centering) Workholder centers all pipe, even over or under size

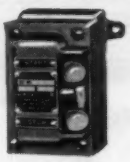
No more crooked threads! 65R pre-sets to size by turn of TC Workholder gauge ring —tightens by palm-of-hand push on forged cam lever. All 3 jaws close together on pipe by one mechanical action. Always straight threads, jamproof, 1″ to 2″ with 1 set of dies, fast size change—only 65R offers you so much for your money. Buy it at your Supply House.

P.S. **The new TC workholder fits your present 65R!**

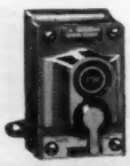
The Ridge Tool Company • Elyria, Ohio, U.S.A.

RIDGID
Work-Saver Pipe Tools

Announcing


EFS-223

EFS-213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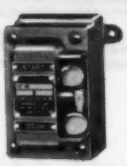
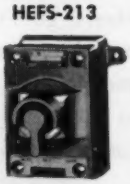
A NEW LINE OF R&S

PUSH-BUTTON and SELECTOR SWITCH STATIONS

EXPLOSION-PROOF and DUST TIGHT


HEFS-223

HEFS-213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EFS and HEFS TYPES

(Class I, groups C & D)

For Surface Mounting

Russell & Stoll announces a new line of compact standard duty EFS and heavy duty HEFS push button and selector switch stations, designed to give long trouble-free service under severe operating conditions in hazardous locations

- These standard duty and heavy duty stations can be used in combination with other Russell & Stoll EFS devices
- Both EFS and HEFS lines include stations with either push button operation or rocker arm control mechanisms—the rocker arm actuated types assure smooth, non-freezing operation under corrosive conditions
- Single and two element stations may be combined into multi-element gang enclosures.

C18

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RUSSELL & STOLL
PRECISION-BUILT ELECTRICAL EQUIPMENT—SINCE 1902

Men in the Industry . . .

Texas, refinery. Brill is now a senior maintenance engineer; Crist a senior project engineer; Schweitzer, a senior design engineer; Tate, a senior civil engineer; and Herndon and Smith are senior electrical engineers.

Edward J. Bieberich has been appointed plant superintendent of the new desiccant manufacturing plant at Gallup, N. M., of Davison Chemical Co. Division of W. R. Grace and Co. In this position, Bieberich will have charge of all purchasing, production and shipping of the company's new desiccant.

George Grimes, refinery superintendent for Cosden Petroleum Corp., has been made general superintendent of the corporation's three refineries. He will be responsible for the opertion, maintenance, and welfare of personnel at the Big Spring, Colorado City, and Hawley, Texas, plants.

Grimes

Grimes has been with Cosden since 1929, when he helped run the first barrel of oil processed by the Big Spring refinery. In 1933, he was made night superintendent. He went to Graham, Texas, in 1939 as superintendent of the Cosden refinery.

Returning to Big Spring in 1945, he was placed in charge of all still operations. The following year, he became refinery superintendent—a post he has held until now.

Charles M. Cole, Jr., has been named chief engineer for Tuloma Gas Products Co. The company is a nationwide marketer of liquefied petroleum gas products.

The position of chief engineer is newly created to supervise the construction and operation of the company's product storage installations, truck terminals, and other supply facilities.

Guy B. Hunter, chairman of the board of Quaker State Oil Refining Corp., Oil City, Pa., was re-elected president of the National Petroleum Association recently at the group's annual meeting. This will mark Hunter's third term as head of the association of oil refiners.

Paul R. Beck, Pennsylvania Refining Co., Butler, Pa., was re-elected first vice president, and **Rexford S. Blazer,** Ashland Oil & Refining Co., Ashland, Ky., was re-elected second vice president.

Hunter, in addition to NPA presidency, also was re-elected treasurer. **E. M. Lyons,** Philadelphia, was re-elected recording secretary, and **Margaret A. Miller,** Washington, D. C., was re-elected assistant treasurer and executive assistant.

James T. Fitzpatrick of Magnolia Petroleum Co.'s Legal department has been transferred from the company's refinery at Beaumont to the Dallas office. **Charles B. Wallace,** vice-president and general counsel for Magnolia, announced the change.

This "heart-failure" can lengthen someone's life!

Pictured above is what happens when a pressure vessel protected by a BS&B Safety Head develops pressures above safe limits. "Heart" of the Safety Head is the rupture disc, which bursts to relieve the overpressure instantly and completely—guarding against injuries to personnel and damage to plant equipment.

BS&B Safety Heads

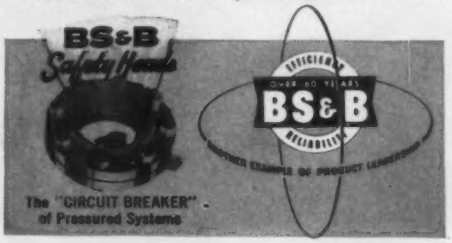
protect pressure systems in every type industry

Thousands of BS&B Safety Heads are today protecting millions of dollars worth of property and equipment and countless human lives. There's a BS&B Safety Head suitable for many types of pressure systems containing air, gas, steam or liquid.

BS&B Rupture Disc—"Heart" of the Safety Head

BS&B rupture discs are designed to relieve pressures at any specified point from 3 to 100,000 pounds per square inch. They are available in standard sizes ranging from ¼ inch to 36 inches in diameter, and in special sizes and types for virtually any application.

If you use any type of pressured system, let us tell you more about BS&B Safety Heads and rupture discs. Call or write your nearest BS&B office or representative—or write to . . .



BLACK, SIVALLS & BRYSON, INC.

Safety Head Division, Dept. 2-F10
7500 East 12th St.
Kansas City 26, Mo.

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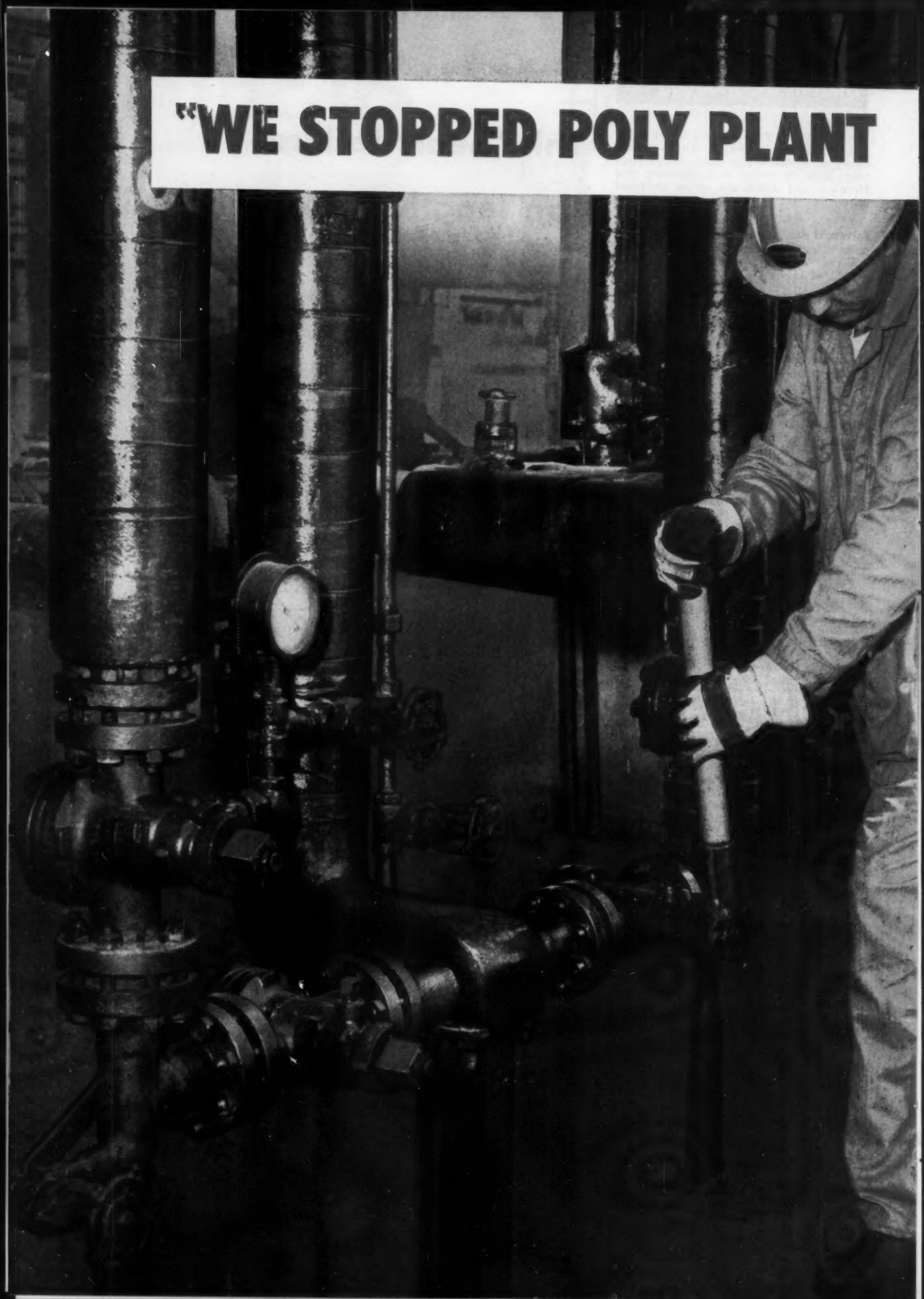
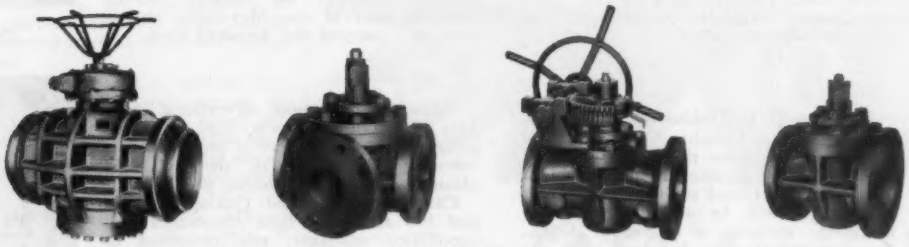

"WE STOPPED POLY PLANT

REACTOR VALVE FAILURES"

At one of the nation's largest refineries, chronic valve problems at their polymerization plant reactors were both costly and troublesome. The continuous high pressures teamed-up with corrosive fluids and abrasive catalyst particles to cause fast valve failures.

On a test installation, Rockwell-Nordstrom lubricated plug valves were installed on inlet and outlet lines to the reactors. *After six months there was no sign of leakage.* In spite of the pressure-corrosion problem the fully protected seats of these valves can't be cut out and lubricant sealing insures a far tighter shut-off than exposed metal-to-metal seats. And lubrication (done simply and quickly while the valve is in service) is preventive maintenance against down time and repair costs.

Rockwell-Nordstrom valves are available in a complete range of sizes and pressures for every refinery flow control need. They cost no more to buy, often less, than ordinary valves. For complete details, call your Rockwell representative or write: Rockwell Manufacturing Company, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.



ROCKWELL- Nordstrom **VALVES**

Lubricant Sealed For Positive Shut-Off

What Suppliers Are Doing . . .

Davies

Robert E. Davies has been named manager of production for Blaw Knox Co.'s Power Piping and Sprinkler division in Pittsburgh. He will have charge of all prefabrication of piping system and fire protection system components for power plants, chemical plants, steel plants, oil refineries, pulp and paper mills, and other industrial installations.

Davies has been with Blaw-Knox since 1950 as construction superintendent for the Chemical Plants division supervising the building of process plants throughout the world. He was formerly associated with the U. S. Geological Survey and U. S. Army Corps of Engineers. He attended Ohio State University and Ohio Weslayan College.

Markle

Alvan Markle has been appointed director of purchases for Walworth Co., manufacturer of valves and fittings, and its subsidiaries. In his new capacity, Markle will be responsible for establishing procurement policies and procedures and for functional control of unit purchasing directors and agents. Markle joins Walworth from Crown Cork and Seal Co. where he had been purchasing manager.

Fugett

Earl G. Fugett has been appointed branch manager of The Cuno Engineering Corp. new sales engineering office at Ardmore, Pa. The Meriden, Conn. firm's new facility, headed by Fugett, serves metropolitan Philadelphia and a surrounding four state area.

In his capacity as branch manager, Fugett will direct Cuno's field sales and service activities in the area. Working with Fugett is **John Toebe,** recently appointed sales engineer. Close engineering contact will continue between the plant and Cuno's customers through the new direct sales-service office.

Jenkins

Frederick C. C. Jenkins has been transferred by The Tretolite Co. division of Petrolite Corp. from the St. Louis office to The Hague. Jenkins has been assistant manager of technical services. In his new position he will be affiliated with the European division of Petrolite Corp., Petrolite Ltd. Jenkins has been with the Petrolite organization since 1953. He served as a naval aviator during World War II, and holds a B.S. degree in chemical engineering from Tafts College.

Walker

Max G. Walker has been appointed sales manager of the Pittsburgh office of Hammond Iron Works. Walker was formerly southeastern sales manager for the company with headquarters in Birmingham, Ala., and is well known throughout the construction and petrochemical industries. Prior to joining Hammond, he spent six years as Chicago district sales manager for Murphy Diesel Co. of Milwaukee. He was also associated with construction projects in petroleum and mining industries of South America. Walker attended Ohio State University and served in the Navy during World War II.

Arrington

A. E. Arrington has been named district manager covering the Rocky Mountain territory of OTM Corp., Houston. His headquarters will be in Denver.

Arrington served as training officer for the government before entering into sales of oil field products and has had experience as a salesman with a manufacturer of oil field equipment and with an oil field supply company. Prior to his appointment as district manager, he was a city salesman in Houston for two years.

Due to OTM's growth, it has been necessary to establish this district sales office to keep in closer contact with fabricators and users of OTM products.

Arrington's office will be located at 721 Salem St., Denver.

Mohr

C. W. Mohr has been named manager of the Industrial Sales department of Gustin-Bacon Manufacturing Co. Mohr will be responsible for the marketing of the company's Industrial materials. This appointment is the first of several directed to the expansion of the business.

Before joining Gustin-Bacon Mohr was sales manager of the Oil Equipment division, Malwaukee Valve Co., Milwaukee.

Siess

Charles P. Siess, Jr., formerly assistant division manager at Anaco, Venezuela for South American Petrolite Corp., has been appointed assistant to **James E. Stockton, Jr.,** general sales manager for the Tretolite Co., division of Petrolite Corp. A graduate of Louisiana State University in 1948 with a B.S. degree in chemical engineering, Siess served more than four years with the company as field engineer.

His duties in South America included working both in the production and the refining phase of the industry. Besides covering part of the Maracaibo region, Siess also covered the Trinidad area.

Carlson

Edward L. Carlson, advertising manager of Oakite Products, Inc., has been placed in over-all charge of the company's informational efforts in the industrial cleaning and metal finishing fields.

Carlson, who joined Oakite in 1924 and has served as both copywriter and production manager, was promoted to advertising manager in 1947. In his new capacity he will supervise the company's activities in industrial trade shows and special promotions, as well as trade paper advertising, direct mail, literature, and publicity.

Barrett

James J. Barrett has been appointed manager of extrusion sales for The Babcock & Wilcox Co's. Tubular Products division. In the newly created position, Barrett will direct the sales extrusions. He will maintain his headquarters at the division's general offices in Beaver Falls, Pa.

A native of Cleveland Barrett joined B&W in 1954, and has been associated with the development of extruded products. He had previously been sales manager of the Gemmer Manufacturing Co., Detroit, and a sales representative in De-

Suppliers . . .

troit for Bishop and Babcock, Cleveland, automotive equipment manufacturers. In 1939, Mr. Barrett participated in the design, development and sale of the first automobile air conditioning unit.

A graduate of Case Institute of Technology with a B.S. degree in mechanical engineering in 1934, Barrett is a member of the American Society for Metals and the Society of Automotive Engineers.

HARBISON-WALKER REFRACTORIES CO. has begun construction of an integrated modern Research Center on a 21-acre suburban site south of Pittsburgh. When completed next year, the million dollar project will house all of the company's research activities.

Earl A. Garber, president, has stated that not only has the company expanded activities into new refractory product fields, such as mullite, silicon carbide and zircon, but that its new facilities in several foreign countries have made available additional raw materials of great promise.

WESTINGHOUSE ELECTRIC CORP'S carrier-microwave department has expanded its facilities in Halethorpe, Md., by constructing a new, modern office building adjacent to the manufacturing plant.

Administrative, sales, engineering, purchasing, and accounting offices are now located in the new building. By moving these offices from the manufacturing plant, manufacturing area has been increased 17 percent to allow a more efficient production layout. Expanded and improved engineering laboratory facilities are now available also. Carrier-microwave started this expansion and improvement in August of 1956 when it became a separate department.

GENERAL ELECTRIC CO. has announced that Creole Petroleum Corp., largest oil producer in Venezuela, has ordered two 8700 KW gas turbine-generator units for its Amuay Refinery from G. E.'s Gas Turbine department.

The units will be used to provide electric power for the refinery's process operation. Adaptable for burning either natural gas or distillate oil, the gas turbines are designed for automatic change-over from one fuel to the other when required.

LEEDS & NORTHRUP, CANADA, LTD., a wholly-owned subsidiary of Leeds & Northrup, Co., Philadelphia has been organized. **I. Melville Stein,** chairman of the board of the new company and president of its parent organization announced.

President of the new company is **J. William Robinson,** formerly of Philadelphia and more recently coordinator of western operations for Leeds & Northrup. The production manager is **J. Robert Gowen,** also formerly with L&N in the west. The office manager is **R. C. Park** of Toronto. Other officers are **D. H. Schultz,** vice-chairman; **S. Loidl Jr.,** treasurer; and **L. A. Blake,** secretary. Gowen is assistant secretary. Directors are Stein, Schultz and Robinson.

ALLIED CHEMICAL & DYE CORP., has appointed **Frederick P. Boehm** manager, Pittsburgh sales branch, Solvay Process division, it was announced by **L. B. Gordon,** vice president.

In his new assignment, Boehm will supervise Solvay's sales activities in western

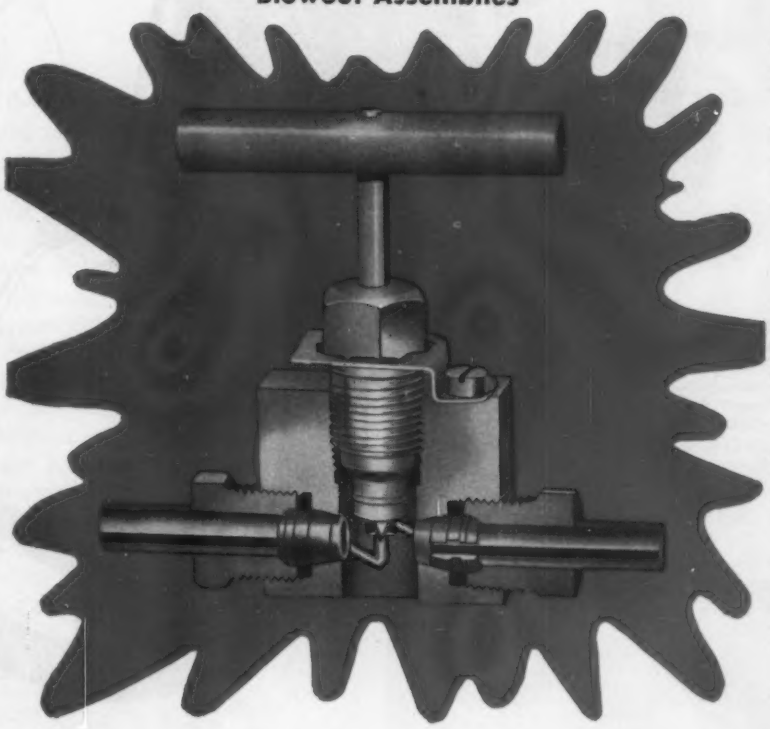
Now Available

ERMETO-type

VALVES and FITTINGS

Tubing . . . Check Valves . . . Line Filters

Blowout Assemblies



For FAST Assembly

HIGH PRESSURE

Systems

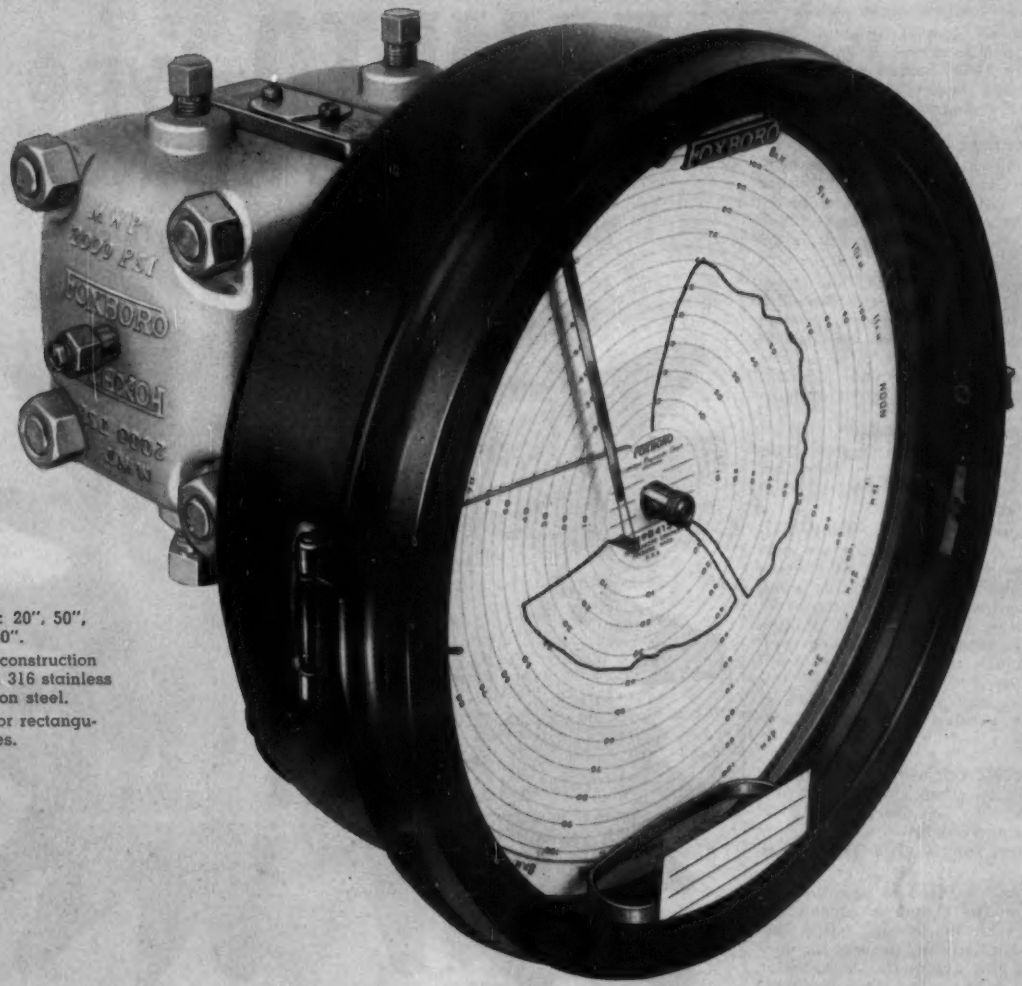
Pressures to 10,000 p.s.i.

Send for New Catalog 407-F-2

AMERICAN INSTRUMENT CO., INC.

8030 GEORGIA AVE., SILVER SPRING, MARYLAND

NOW... a "Dry" Flow Meter with...

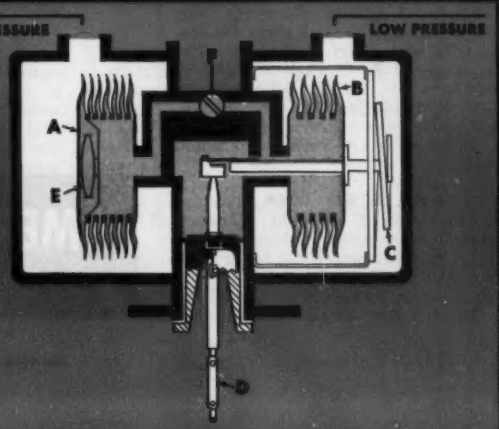


- Ranges: 20", 50", 100", 200".
- Forged construction in Type 316 stainless or carbon steel.
- Round or rectangular cases.

..the new Foxboro Type 37 Diaphragm Meter

How It Works

In schematic drawing at right, areas shown in color represent a stable, non-freezing liquid. Any pressure increase in the high pressure chamber compresses Diaphragm Unit A, displacing its liquid and expanding Diaphragm Unit B until force of Range Spring C equals the difference between the forces on Diaphragm Units A and B. Linear motion of Diaphragm Unit B moves inner end of Drive Bar D — outer end moves correspondingly through the bellows-sealed flexure bar, driving pen arm. Built-in Temperature Compensator (E) proportionately adjusts diaphragm capacity as ambient temperature variations affect volume of filling fluid. External damping adjustment is shown at F.



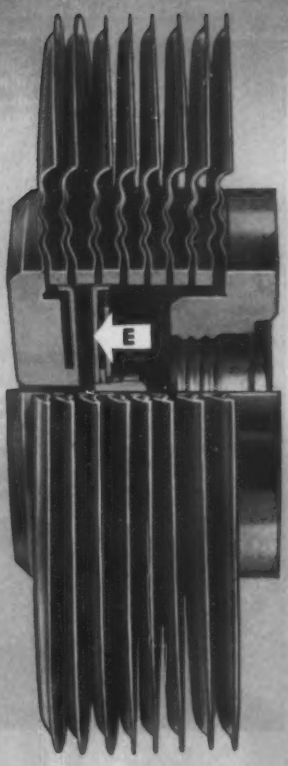
- *complete overrange protection!*
- *sustained high accuracy!*

Now you can have mercuryless flow measurement for a wide range of differential pressures — at static pressures up to 2000 psi — with greater safety and dependability than ever before! The new Foxboro Type 37 Diaphragm Meter not only combines unmatched ruggedness and precision in a dry meter — it's by far the easiest to adjust and maintain. And it does away with zero drift problems, once and for all! Expansible, Type 316 S.S. diaphragm elements respond to changes in pressure with unmatched sensitivity, yet are completely immune to overrange up to full static pressure! A unique packless drive bar precisely transmits linear motion to the pen arm. Range-changing is easy, due to new twin-spiral spring design. Wide range damping is externally adjustable under pressure. And the Type 37 is self-compensating for temperature changes in all differential ranges. Get full details on this high utility, completely dependable dry flow meter. Arrange for a demonstration with your nearby Foxboro Field Engineer, or write **The Foxboro Company, 7410 Neponset Ave., Foxboro, Mass., U.S.A.**

FOXBORO

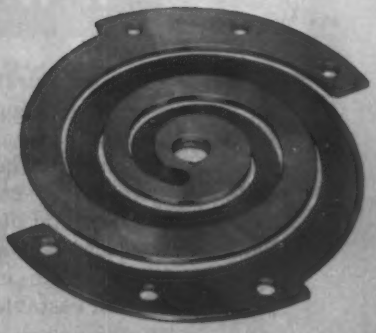
REG. U.S. PAT. OFF.

FIRST IN FLOW METERING



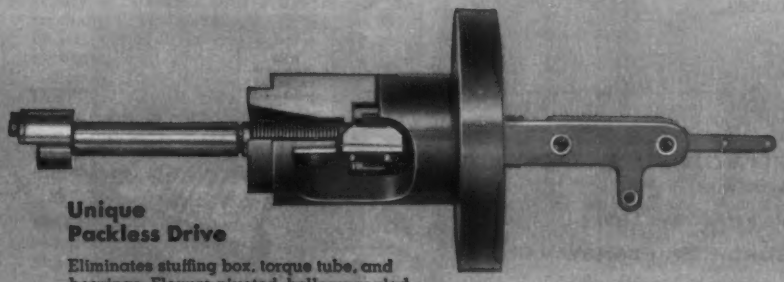
Exclusive Diaphragm Elements

Type 316 S.S. diaphragm units in both high and low pressure chambers provide greatest linearity and freedom from hysteresis; nesting design and integral spacer rings provide safe, positive, overrange protection. Temperature compensation (E) is built into diaphragm assembly . . . *never* requires change or adjustment.



Exclusive Range Springs

Heavy gauge Ni-Span C alloy, twin-spiral springs provide high sensitivity with lasting accuracy. Readily accessible . . . range changes are easily made, in minutes!



Unique Packless Drive

Eliminates stuffing box, torque tube, and bearings. Flexure-pivoted, bellows-sealed drive bar transmits diaphragm's linear motion to the pen arm with unequalled sensitivity *and undiminished* power. Seal for flexure pivot is a tough, flexible bellows.

GUN APPLICATION—For many installations, Harbison-Walker castables are used to best advantage with various types of air placement guns.

TROWELLING—This method is preferred for some applications and the excellent working qualities of Harbison-Walker castables make them easy to use and to secure uniform durable linings.

For refractory linings that last longer...
specify HARBISON-WALKER

H-W EXTRA STRENGTH CASTABLE

H-W 56 LIGHTWEIGHT CASTABLE

Used together as illustrated, these two Harbison-Walker castable refractories form a lining that withstands the erosion, temperatures and pressures of refinery units, and provides highly effective insulation that reduces heat losses. Both products are particularly suited for service in catalytic cracking regenerators, reactors, catalyst feed lines and other units. They can be trowelled, poured like concrete, tamped or applied with air guns.

Write for complete information about these refinery-proved Harbison-Walker castable refractories.

Cross-sectional view shows H-W 56 Lightweight (insulating) Castable next to the regenerator shell, with H-W Extra Strength Castable superimposed for the working lining, where its high strength, excellent erosion resistance and low coefficient of expansion all contribute to long service life.

Harbison-Walker Refractories Company
AND SUBSIDIARIES

World's Most Complete Refractories Service

GENERAL OFFICES: PITTSBURGH 22, PENNSYLVANIA

Pennsylvania and West Virginia. Boehm first joined Solvay in 1940 shortly after receiving his B.S. degree in chemistry from Texas Western College. Assigned to the technical service department, he was subsequently named manager of Solvay's ammonium and potassium products section.

NORTON CO. has announced a change in the organization of the Electro-Chemical division and the Refractories division.

Harlan T. Pierpont has been appointed manager of sales, Electro-Chemical division, and has also become a member of the operating board for this division. **Frederick J. Rutland** is now manager of sales engineering for the Electro-Chemical division. Pierpont was previously sales manager of the Refractories division, and Rutland sales engineer at Norton's Chippawa, Ontario plant.

Frank B. Huke, formerly chief atomic products engineer, was made manager of Atomic Product sales, Refractories division. **George H. Powers,** formerly assistant sales manager of the Refractories division, is now manager of distribution for this division.

A graduate of Harvard University, Pierpont joined Norton Company in 1935.

Rutland, a native of Canada, attended Malvern Collegiate and Central Technical School in Toronto. He joined Norton Company's Chippawa branch in 1935.

Huke is an alumnus of North Central College, Naperville, Ill., and also attended the University of Chicago and Iowa State College. He served as a chemical engineer on the Manhattan Project, and before joining Norton in 1954.

Powers is a graduate of Clark University, and did graduate work at the University of Connecticut and Massachusetts Institute of Technology. He served with the Corps of Engineers on the Manhattan Project at Oak Ridge, during World War II. In 1946 he joined Norton Company.

CHICAGO BRIDGE & IRON CO. has announced that **E. S. Fraser,** formerly manager of the company's Salt Lake City plant has been named assistant general sales manager with headquarters in Chicago.

Buell Moore who has been in the company's Engineering department at the Birmingham plant since 1949 has been assigned to the New York sales office.

Elwood Garrett, recently in the Houston erection district, has been assigned to the New Orleans sales office.

Fraser who joined CB&I in 1939 has worked in the Chicago plant, Chicago Engineering and Research department and was superintendent of the Salt Lake City plant and later manager of the plant before being transferred to Chicago. Fraser graduated from the University of Illinois with a B. S. degree in civil engineering in 1939.

Buell Moore graduated from the University of Alabama with a B.S. degree in mechanical engineering in 1949. In 1954 he was named design engineer at the Birmingham plant.

Elwood Garrett was graduated in 1950 from the University of Alabama, with a B.S. degree in civil engineering. He has worked in the Birmingham shop and Birmingham erection district prior to being in the Houston erection district.

TUBE TURNS has appointed **S. Merle Hardison** district manager in Philadelphia. The announcement was made by **John G. Seiler,** president of Tube Turns, a division of National Cylinder Gas Co.

Hardison succeeds **W. E. Geiser,** who has returned to the headquarters staff in Louisville and has been assigned to an important phase of the company's expansion program.

Hardison attended the University of North Carolina and Wake Forest College. He joined Tube Turns in 1941 and was associated with sales-engineering staffs before moving to Philadelphia in 1948.

Geiser joined Tube Turns in 1929, shortly after the company was established, and was Southeastern district manager from 1935 to 1940, when he was placed in charge of the company's activities in the shipbuilding field. In 1942, he was made district manager at Philadelphia.

Suppliers . . .

FISHER GOVERNOR CO.'s plant at Marshalltown, Iowa, was the scene recently of a two-day visit of men from the chemical and petroleum industries of the Houston and Corpus Christi areas of Texas.

A group of 32 representatives spent considerable time in studying Fisher production operations, after which research and engineering department personnel spoke on developments in the Houston and Corpus Christi areas.

Companies represented included Rohn & Haas, Neches Butane Products Co., The Shell Oil Co., Foster-Wheeler Co., Crown

On ungrounded 440 v. 3-phase systems

THIS ELECTRONIC DEVICE GIVES YOU AUDIO-VISUAL....

WARNING

....before those hidden grounds become dangerous and costly!

By warning of trouble before it becomes serious, the DELTA-DESCO GROUND ALERT saves in many ways. Saves expensive motor rewinding, switch gear and transformers, and prevents crippling shut-downs. At the same time it reduces the possibility of fire hazards and personnel injury.

HOW IT WORKS! When ground resistance drops to 7,500 ohms in any phase of the 440 V. 3-phase ungrounded circuit, the *green light goes off*, a bell inside the instrument starts to ring and the *red light comes on*. The bell continues to ring until switched off and the red light burns until the ground is corrected. As long as all phases are ground-free the green light burns. Available in portable or stationary model.

Don't wait until trouble strikes . . .

DELTA-DESCO *Electronic* GROUND ALERT

WRITE FOR DESCRIPTIVE BOOKLET -TODAY!

DELTA-DESCO COMPANIES

Delta Engineering Sales Co.

539 Aero Drive

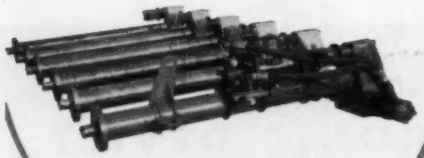
Shreveport, Louisiana

For more data on advertised products, use Readers' Service Cards, last page.

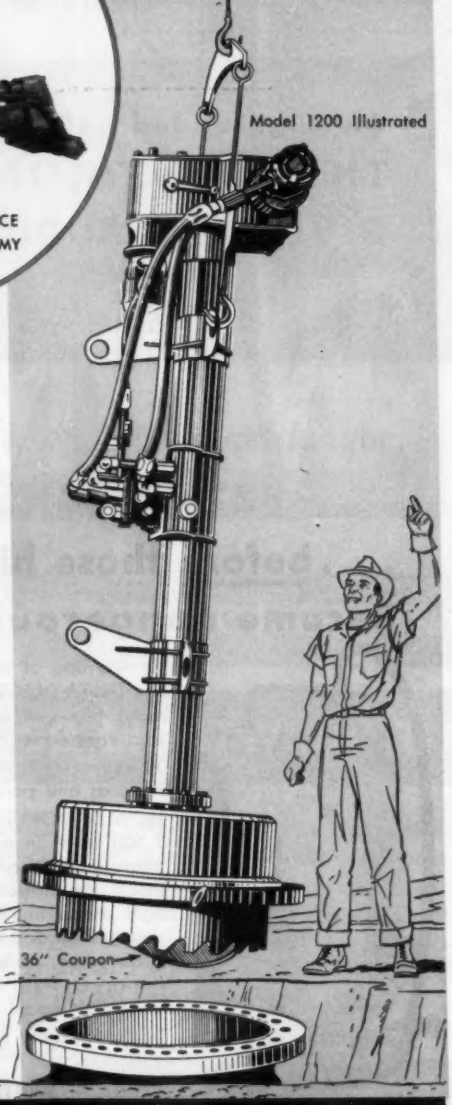
It costs no more for the very best!

WmSON-HILLCO TAPPING MACHINES

QUALITY CONTROLLED VOLUME PRODUCTION



. . . YOUR ASSURANCE OF LASTING ECONOMY



Model 1200 Illustrated

MODELS: 1200, 660, 360 & 100-B
ANY SIZE TAPS UP TO 36"

EXCLUSIVE FEATURES:

- HARD CHROMED BORING BAR & SELF ADJUSTING PACKING
- WIDER RANGE OF TAPS WITH IMPROVED POWER SYSTEMS
- HEAVY DUTY BEARINGS AND DRY FILM LUBRICATION

ALL MODELS RATED AT:
1,440 PSI @ 100° F or
700° F @ 700 PSI
EACH MACHINE TESTED TO 2,175 PSI

Write for RENTAL-PURCHASE information & bulletins

36" Coupon

PIPELINES REFINERIES CHEMICAL PLANTS STEEL MILLS

T.D. Williamson, Inc.

P. O. BOX 4038 TULSA 9, OKLAHOMA

REPRESENTATIVES: HOUSTON • AMARILLO • PITTSBURGH • PLAINFIELD, N.J. • JOLIET, ILL. • JACKSON, MICH. • LOS ANGELES • SAN FRANCISCO BARTLESVILLE, OKLAHOMA • SEATTLE • SALT LAKE CITY • EDMONTON TORONTO • WINNIPEG • VANCOUVER • BUENOS AIRES • CABIMAS, ZULIA, VENEZUELA • DURBAN, NATAL, S. AFRICA • PARIS, FRANCE • SIDNEY, AUST.

Suppliers . . .

Central Petroleum, Brown and Root, Inc., LaGloria Oil & Gas Co., Union Carbide, The Dow Chemical Co., and Eastern States Petroleum.

Others were Tellepsen Petro-Chemical Co., Fish Engineering Corp., Texas Butadiene & Chemical Corp., Texas Gulf Sulphur Co., Columbia Southern Chemical Corp., Central Power & Light Co., Celanese Corp. of America, American Chemicals Corp., Creole Petroleum Co., American Oil Co., The Pure Oil Co., American Chemicals Corp., and The Lummus Co.

E. I. DU PONT DE NEMOURS & CO., INC., has established new warehouse facilities at its Petroleum Chemicals division at Mt. Vernon, Wash. All types of Du Pont products, will be stocked at the new facilities, which supplement those already in operation at Los Angeles, Chicago, Kansas City, Mo., Houston, and Billings, Mont.

JEFFERSON CHEMICAL CO. has appointed **William C. Bedoit, Jr.** manager, Market Development, of the company's Commercial Development division. Dr. Bedoit assumed his new duties September 16th and is now responsible for all phases of market development.

Dr. Bedoit has been a senior research chemist at Jefferson's Austin, Texas research laboratories since 1954. He received his Ph.D. degree from the University of Tennessee in 1950.

THE TIMKEN ROLLER BEARING CO'S. board of directors has appropriated $500,000 for installing a consumable electrode vacuum electric furnace. The furnace will be incorporated in the Melt Shop by extending the charging section of the Melt Shop building an additional 63 feet. Capacity of the furnace will be 5 million pounds per year.

John Fick, vice president of the Timken's Steel and Tube division said that the new vacuum furnace will produce a cleaner, sounder steel with very high fatigue strength, and ductility. Construction of the building to house the new furnace, and its subsequent installation will require from eight to nine months, with June 1, 1958, set as a target date for completion.

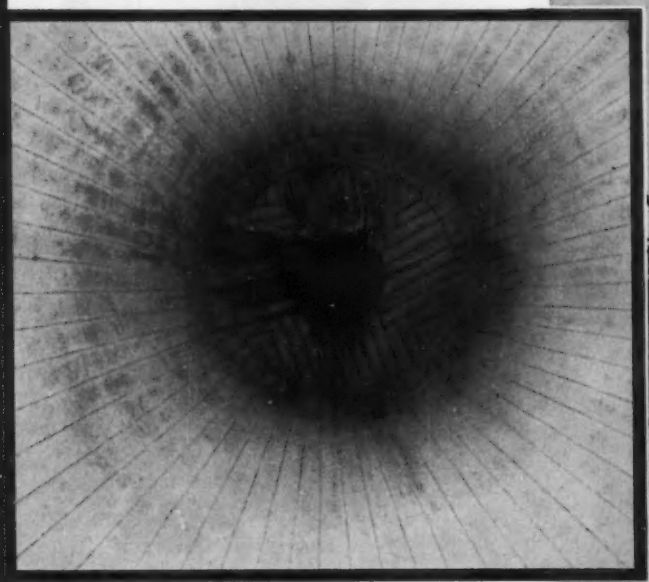
THE LUMMUS CO. has announced the sale of its heat exchanger manufacturing division, with plant located at Honesdale, to Yuba Consolidated Gold Fields.

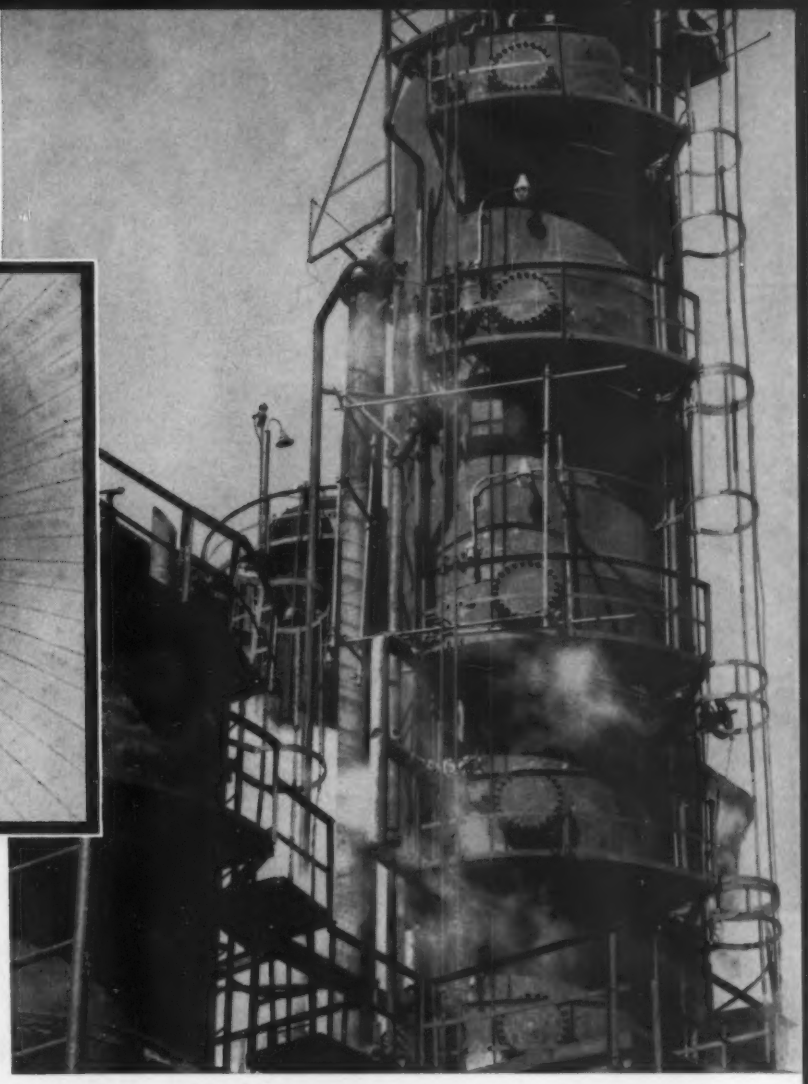
J. F. Thornton, president of Lummus, announced that this move conforms with the company's recent decision to divest itself of its manufacturing divisions in order to concentrate on its main activities—engineering and construction. Headquarters for these activities are maintained in New York with branches in Houston and Chicago, and wholly owned subsidiaries in Montreal, Paris, London, The Hague, Caracas and Bombay. The first move in carrying out the new policy was the sale of Lummus' pipe fabrication plant at East Chicago, Ind., in the fall of 1956.

INTERNATIONAL NICKEL CO.'s Research Laboratory at Bayonne, N. J., has added **Dr. Ralph B. G. Yeo** as a member of the Steel Research section. He will be concerned initially with the effects of alloying elements upon the performance of

For more data on advertised products, use Readers' Service Cards, last page.

The fractionation unit on the right is lined for ⅔ of its height with Stainless Steel 410. The flash tower at left is 35% lined with Stainless Steel, primarily in flash zone.





No repair or replacement necessary after six years' service! The vessel shown here has been in continuous service for six years purifying sour gasoline. It is now being switched to another type of service. The condition of the Stainless Steel 410 lining is so good that no repair or replacement is necessary.

Not one single failure of STAINLESS STEEL tower lining for Eastern States Petroleum Company

At plant #1 of Eastern States Petroleum Company, Houston, Texas, high temperature sulfur corrosion caused by sour crude systematically destroyed every carbon steel tower in the plant. As these failures occurred, all towers were replaced with Stainless Steel lined equipment. Since the installation of the Stainless Steel, not one lining failure has been reported.

All new equipment installed since 1949 has also been lined with Stainless Steel and again, no failures have occurred. Most of the Stainless used for this type of application is USS Stainless Steel Type 410.

USS Stainless Steel has long proved that it has the ability to stand up under the extremely corrosive, high temperature, high pressure conditions associated with refinery operation. For this reason Stainless Steel has wide application in all types of refineries.

For fast delivery of Stainless Steel, call your local steel distributor. Let his stock serve as your inventory.

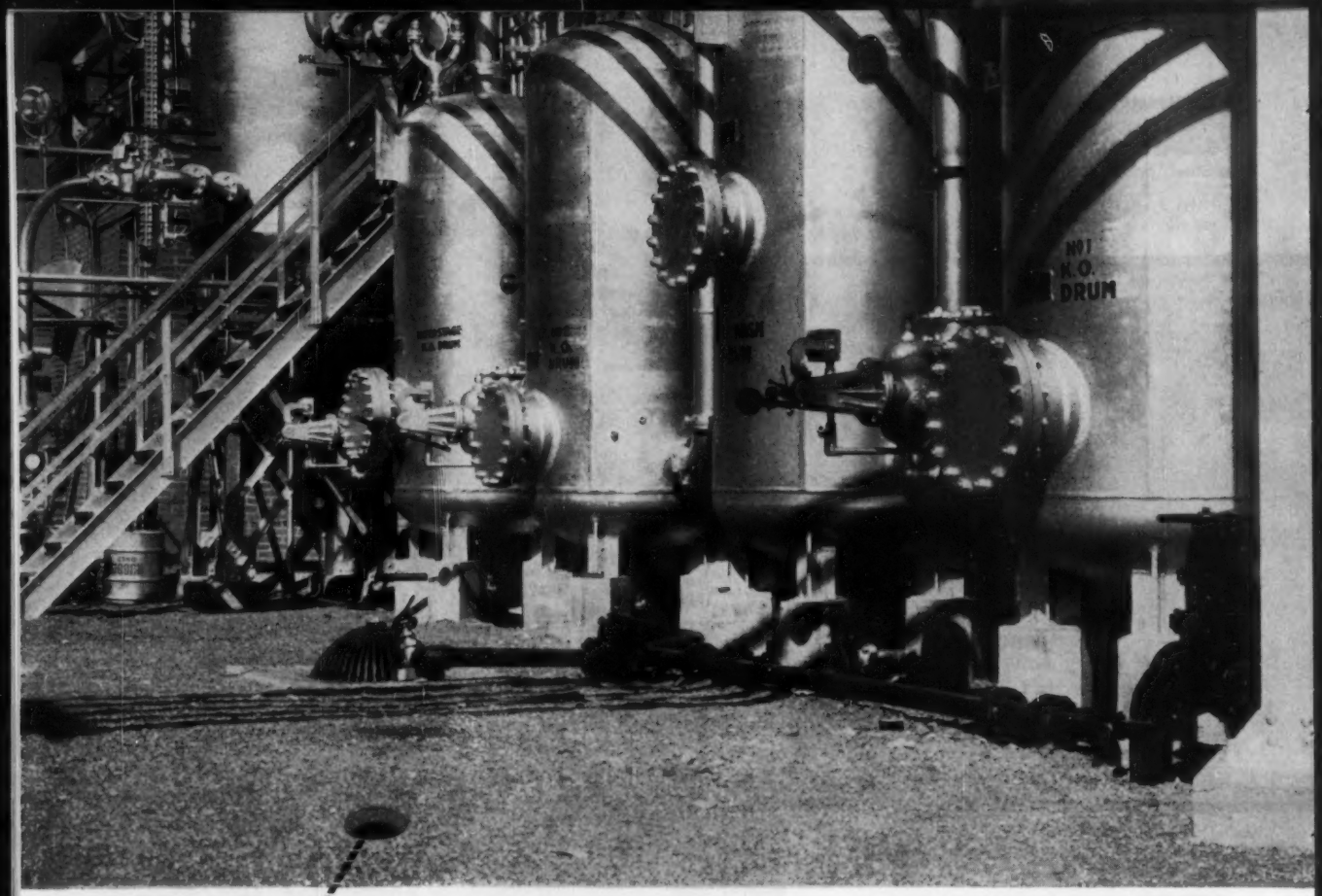
United States Steel Corporation, Pittsburgh • American Steel & Wire Division, Cleveland • Columbia-Geneva Steel Division, San Francisco
National Tube Division, Pittsburgh • Tennessee Coal & Iron Division, Fairfield, Ala. • United States Steel Supply Division, Warehouse Distributors
United States Steel Export Company, New York

USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS • PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

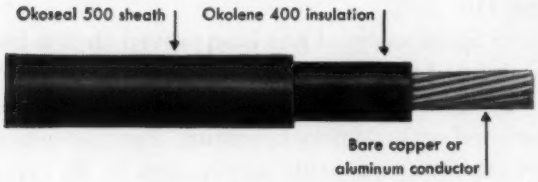
UNITED STATES STEEL



let soil samples from your refinery show you why!

never take cathodic protection for granted

Cathodic protection is no more effective than the cable that carries the protective current. And factors that materially shorten the life of ordinary cable are especially prevalent around petroleum refineries and petrochemical plants. Your own



soil may reveal many destructive agents such as petroleum oils, paraffinic hydrocarbons, mineral acids, alkalies and esters.

Okonite Cathodic Protection Cable has been especially engineered for optimum chemical and mechanical protection in direct burial installations where such conditions occur. This cable, insulated with Okolene 400 (a polyethylene compound) and sheathed with Okoseal 500 (a polyvinyl chloride compound), has been thoroughly tested in the lab and service-proved in the field.

Dimensions, electrical characteristics and a recommended typical connection method for cathodic protection cable are given in Bulletin PR-2127. Write for this free technical information bulletin to The Okonite Company, Passaic, New Jersey.

4325

***where there's electrical power... there's* OKONITE CABLE**

Suppliers . . .

carburizing steels and with the development of steels for use as large forgings.

Dr. Yeo spent his early years in Wales where he was graduated by the University College at Cardiff with a B.S. degree. He continued studying metallurgy at Birmingham University in England and was awarded a Ph.D. degree in 1956. His thesis dealt with stabilization of the austenite-martensite transformation in various steels.

During the period, 1953-1956, Dr. Yeo held the post of Lecturer in the Metallurgy department, University of Witwatersrand, Johannesburg, South Africa.

ROCKWELL MANUFACTURING CO., board chairman **Col. Willard F. Rockwell,** has been appointed to the National Defense Committee of the U. S. Chamber of Commerce for a term of one year.

The appointment was announced by **Philip M. Talbott,** president of the Chamber, at its national headquarters here in Washington, D. C.

Col. Rockwell, a former Assistant Secretary of Defense and current national chairman of the Association of the U. S. Army, will "help develop Chamber policies and programs to meet problems affecting national defense," Talbott said.

"The board of directors of the Chamber and its entire membership depend heavily on the committee for advice and leadership. Col. Rockwell's knowledge of national problems in this field will enable him to contribute greatly to the work of the Committee," he added.

DE LAVAL STEAM TURBINE CO., Trenton, N. J. and **John Holroyd & Co., Ltd.,** Milnrow, Lancashire, England, have announced an agreement whereby both companies, having background in engineering, manufacturing and marketing of worm

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STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, and JULY 2, 1946 (Title 39, United States Code, Section 233) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF PETROLEUM REFINER, published monthly at Houston, Texas, for October, 1957.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Ray L. Dudley, 3371 Chevy Chase, Houston, Texas; Editorial Director, Silas B. Ragsdale, 1636 North Blvd., Houston, Texas; Editor, George Gibbs, 9214 Timberside Dr., Houston, Texas; Managing Editor, Wallace Fitzgerald, 1514 Hewitt Drive, Houston, Texas; Business Manager, Robert M. de Sombre, 4410 Ingersoll, Houston, Texas.

2. The owner is: The Gulf Publishing Company, Houston, Texas; June Wooden Bliss, Houston, Texas; June Wooden Dudley Bliss—Trustee, Houston, Texas; Mrs. Grace C. Carter, Dallas, Texas; Mrs. Margaret D. Cashman, Beaumont, Texas; Drum & Company, c/o Trust Department, Houston, Texas; P. Stinson Dudley, Eldorado, Texas; Ray L. Dudley, Houston, Texas; William G. Dudley, Houston, Texas; William V. Gross, Alpine, Texas; Mrs. Carolyn Dodson Keeble, Abilene, Texas; Mrs. Anita S. Lane, Houston, Texas; Charles H. Lane, Houston, Texas; James William Nelson, Baytown, Texas; Tom W. Nelson, Houston, Texas; Mrs. Sallie Windham Ridley, Houston, Texas; Walter Gage Sterling—Trustee, Houston, Texas; O. R. Waller, Chicago, Illinois.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: NONE.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

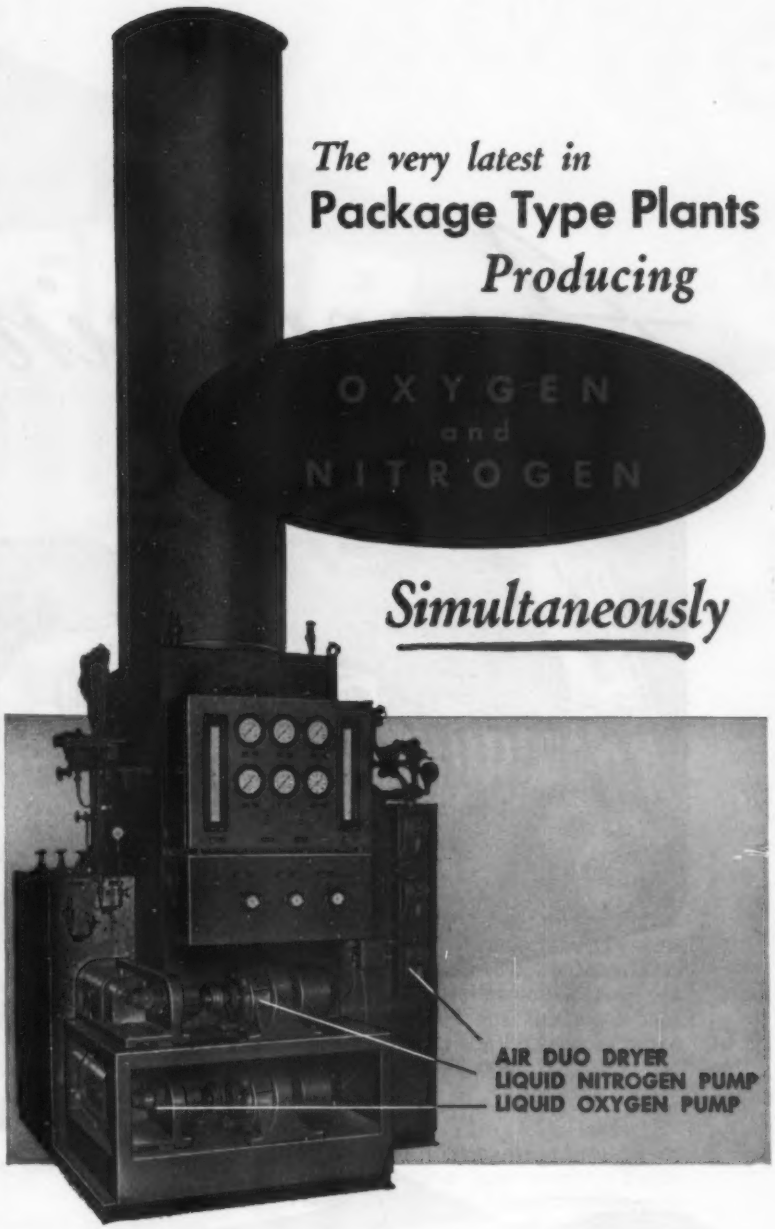
5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semiweekly, and triweekly newspapers only.)

R. M. de SOMBRE
Business Manager

Sworn to and subscribed before me this 18th day of September, 1957.

F. J. AUCOIN
(Seal) Notary Public in and for Harris County, Texas.
(My commission expires June 1, 1959.)

The very latest in
Package Type Plants
Producing
OXYGEN and NITROGEN
Simultaneously



With the introduction of our latest, improved design Package Type Generating Plants, production of high purity Oxygen and Nitrogen simultaneously *increases* production 60% over the production of Oxygen alone, *plus* a corresponding reduction in the *cost* of manufacture. Due to its compact design, a minimum of floor space is required and streamlined panel assembly insures instant visibility of all control gauges. Stock sizes from 1500 to 10,000 cu. ft. per hour. Larger and smaller sizes available. 99.99% Argon available on large size plants.

We invite your inquiry.

INDEPENDENT ENGINEERING COMPANY, Inc.
Manufacturers of
CONSULTING IECO DESIGNING
CYLINDERS AND GAS PRODUCING EQUIPMENT
ACETYLENE - OXYGEN - NITROGEN - ARGON
O'FALLON 6, ILLINOIS

For more data on advertised products, use Readers' Service Cards, last page.

Announcing the.....

Manufacturers of: PRESSURE REGULATORS, DIAPHRAGM VALVES

FISHER GOVERNOR COMPANY

FISHER®

TYPE 3541

E POSITROL

. . . a fast, sensitive electro-pneumatic valve positioner for dependable, accurate valve control

The FISHER E-POSITROL combines the advantages of fast transmissions from electronic controllers with the economy and dependability of pneumatically operated control valves.

The Type 3541 E-POSITROL consists of two units, First: The Type 541 Transducer, which produces a pneumatic out-put pressure that is proportional to a DC electrical in-put signal, Second: A pneumatic valve positioner (Type 3500) which accurately positions the valve stem as dictated by the pneumatic out-put pressure of the transducer.

A most important feature is that any FISHER Type 3500 Positrol valve positioner now in service can easily be converted to an electro pneumatic positioner by adding the transducer portion.

The transducer is attached to the side of a standard "Positrol" case and is available with different coils capable of utilizing a signal from any electronic instrument within the DC signal range of from .3 ma to 50 ma.

The transducer case is of explosion proof design. The FISHER E-POSITROL can be mounted on direct or reverse acting top works. Tests prove that stability, repeatability and frequency of response on this unit are excellent.

For full details write for Bulletin E-3541.

and LIQUID LEVEL CONTROLS

FISHER® Controls

Marshalltown, Iowa/Woodstock, Ontario

Since 1880

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

gear power transmission equipment in the United States and the United Kingdom, will pool their engineering and manufacturing resources.

J. P. Stewart, president, De Laval Steam Turbine Co. and **E. O. Liebert,** chairman, John Holroyd & Co., Ltd., announced the formation of a new jointly owned company, **De Laval-Holroyd Inc.,** which will eventually establish manufacturing facilities with the modern production equipment.

Initially De Laval Steam Turbine Co. will market worm gear reducers manufactured by Holroyd in England, in addition to its own line.

ASEECO, INC., division of Associated Engineering & Equipment Co., Houston, has announced that its long-range plan for achievement of national distribution for Aseeco aluminum jacketing is progressing "much more rapidly" than originally anticipated and the company now has 32 distributors providing marketing coverage in 40 states and Alaska. This was made known by **Ed Tracey,** general sales manager.

The company manufacturers aluminum jacketing for insulated lines, towers, tanks and vessels. Aseeco, Inc., was organized in October, 1956. Initially, sales efforts were concentrated in the South and Southwest with particular emphasis on the oil and petrochemical industries where this type of insulation protection attained its first strong acceptance.

ALLAN EDWARDS, INC., Tulsa equipment engineering firm, has added **Tom Barnard, Elmo Morrison** and **Don White** to its Tulsa staff.

Barnard formerly was with Warren Petroleum Corp. and Aljo Sales, Inc. He attended the University of Tulsa and the University of California.

Morrison moved to Tulsa from California where he was sales manager for an industrial company. He also worked in the tank engineering department of Service Pipe Line Co.

White is a native Tulsan and attended the University of Tulsa and Oklahoma State University. He formerly worked for National Tank Co. and Douglas Aircraft Co.

MARSH INSTRUMENT CO. and affiliates have announced the appointment of **Robert E. Barnett** to the position of sales manager.

Barnett joined the Marsh sales staff in 1941 and was appointed assistant sales manager in 1950. He attended Armour Institute of Technology and the Central YMCA College.

S. MORGAN SMITH CO. has moved all valve operations from its R-S Plant in Philadelphia to the main plant in York, Pa. In addition to improving the productive facilities, this advance is planned to lower manufacturing costs and shorten delivery time.

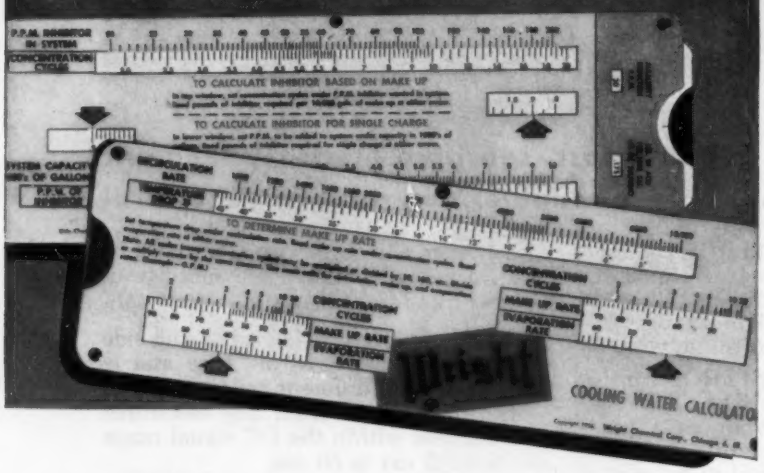
WOLVERINE TUBE, Division of Calumet & Hecla, Inc., has appointed **Robert Allan** representative in Grand Rapids, Mich., and surrounding area. He will be replacing **S. C. Seekell.**

Formerly sales representative of Wolverine Tube in Kansas City, Allan will headquarter in Wolverine's Grand Rapids office.

WESTINGHOUSE ELECTRIC CORP. has appointed **David C. Fulton** manager of the heat transfer apparatus department for the steam division. Fulton was manager of the marine section steam sales department.

Born in Victoria, B. C., Fulton received a B.S. degree in electrical engineering from Oregon State College. He joined Westinghouse in 1939 at East Pittsburgh,

Announcing the New WRIGHT
Cooling Water Calculator



. . . for Efficient Cooling Water Operation

USE IT WITH OUR COMPLIMENTS to help you keep your cooling water system operating with day-to-day efficiency.

Developed by Wright Engineers, the new calculator will quickly answer these problems:

- Evaporation rate. • Determine Make-up rate.
- Amount of inhibitor required — based on Make-up.
- Amount of inhibitor required for single charge.
- Amount of acid addition required.

We know you'll find the new calculator a valuable aid in your work — and, of course, a Wright Engineer will gladly survey your water system and submit a comprehensive water conditioning program. Without obligation.

The Wright Calculator will be sent free to water treating engineers and others responsible for protection of water systems. Please send your request on a company letterhead to:

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Offices in Principal Cities
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PETROLEUM ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON TEFLON® tetrafluoroethylene resins

Superior sealant properties of TEFLON® (tetrafluoroethylene resins) resins prevent losses... reduce maintenance

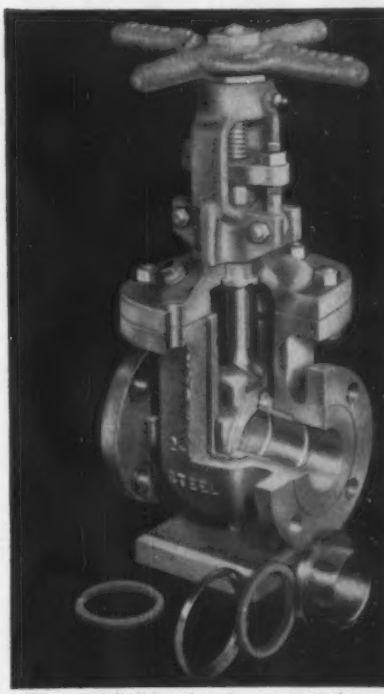
Seals, gaskets and packings of Du Pont TEFLON tetrafluoroethylene resins give outstanding service in pipelines and process equipment. Sealing devices of TEFLON resins have amazing durability, even under the most adverse conditions.

In the case of the gate valve pictured, TEFLON resins were selected after consideration of several seal materials. A TEFLON resin is specified because of chemical inertness, lack of tendency to swell or crack, its toughness and durability. TEFLON resins provide a tight, leakproof seating for the gate. Valve operation is more efficient, and maintenance costs are sharply reduced.

Most of the mechanical strength properties of molded TEFLON 1 or TEFLON 5 are comparable with those of the best grades of rubber-bonded compressed asbestos. In addition, TEFLON resins have a naturally slippery surface, which facilitates operation of mechanical parts. Designers take advantage of this property to make "self-lubricating" bearings and bushings. TEFLON resins are tough and strong, and are used to make structural elements. Rated for use up to 500°F., TEFLON tetrafluoroethylene resins show no brittleness at temperatures as low as that of liquid helium.

Du Pont TEFLON resins are unaffected by petroleum distillation products, catalysts and reagents. They are completely inert to acids, aliphatics, aromatics, chlorinated hydrocarbons—virtually all chemicals and solvents in commercial use. The few exceptions to this include attack by the alkali metals under certain conditions. At high temperatures and pressures, halogens and certain halogenated chemicals and solvents may also affect TEFLON resins.

The next time design of a juncture or closure presents problems of leakage and excessive maintenance, look into the possibility of using Du Pont TEFLON tetrafluoroethylene resins. Additional material on this subject is available. Just mail the coupon.



SEAL RINGS in this gate valve are made from one of the TEFLON tetrafluoroethylene resins. Natural lubricity of TEFLON resins decreases torque needed to open valve and eliminates sticking or freezing. TEFLON resins are chemically inert, even at high temperatures. (Valve by Hamer Valves Inc., Long Beach, California.)

Pipes lined with TEFLON® resins resist corrosives and high temperatures

Steel pipe lined with a TEFLON resin is ideal for use in oil-field and petrochemical process equipment, because TEFLON resins have practically universal chemical inertness. In most cases, too, gaskets are unnecessary, because the ends of the liner may be flared over the faces of steel flanges. TEFLON tetrafluoroethylene resins can be employed in continuous processes running at 500° F. Sticky, viscous fluids have little tendency to adhere to the naturally "waxy" surface of the liners.

TEFLON®

is a registered trademark...

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the tetrafluoroethylene resins discussed herein. This registered trademark should not be used as an adjective to describe any product, nor should it be used in whole, or in part, as a trademark for a product of another concern.

SEND FOR INFORMATION

For additional property and application data on Du Pont TEFLON tetrafluoroethylene resins, mail this coupon.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 369, Du Pont Building, Wilmington 98, Delaware

Please send me more information on Du Pont TEFLON tetrafluoroethylene resins. I am interested in evaluating TEFLON for_____

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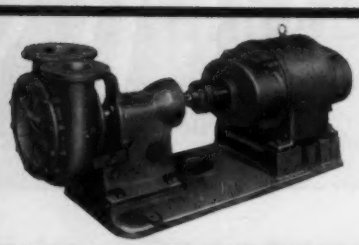

Fig. 3715 single-stage, side-suction centrifugal pump with capacities to 800 GPM and heads to 300 ft. In 10 sizes from ¾" to 3". Temperatures to 350°F. Send for Bulletin 725.4.

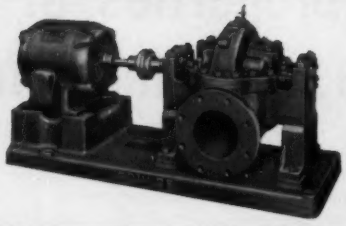

Fig. 3405 single-stage, double-suction centrifugal pump with capacities to 6400 GPM and heads to 425 ft. In 33 sizes from 3" to 12". Temperatures to 350°F. Request Bulletin 721.6.

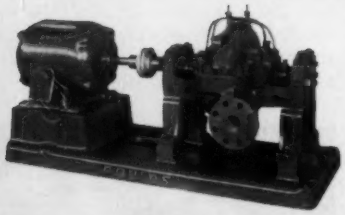

Fig. 3305 two-stage, opposed-impeller centrifugal pump with capacities to 1200 GPM and heads to 1000 ft. In 8 sizes from 1 ½" to 4". Temperatures to 350°F. Described in Bulletin 722.6.

How to keep salt water from chewing holes in your pump budget

Does salt water give your pump ulcers?

You can stave off this costly damage with a pump alloy that's both tough and hard — Nickel-Aluminum-Bronze (Goulds No. 1121).

Your pumps will resist abrasion, too, if they're Goulds pumps built with this new alloy. Toughness and hardness in Goulds 1121 Bronze (Nickel-Aluminum-Bronze) combine to give a high degree of resistance to abrasion, excellent resistance to failure from attack by sand, salts, slurries, and cavitation erosion. Here's how this special material performs:

1. Resists salt water pitting better than chromium stainless steels by 3 to 1.

2. Withstands cavitation erosion better than 18-8 steels by 2 to 1.

3. Holds down salt water corrosion better than standard manganese bronze by 12 to 1.

You can get this extra protection against destructive salt water—in the three pumps shown above. Just specify the fluid end in Goulds 1121 Bronze.

To meet other tough corrosive conditions, choose any of these pumps in Gould-A-Loy 20, 316 stainless, leaded bronze, all iron, or bronze fitted. No matter which one you choose, you'll get quick delivery from factory stock.

If you want more specific information on any of these pumps, send for the bulletins listed in the illustration.

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Seneca Falls, N. Y., Main Office and Works

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BOSTON, Room 314, 1330 Beacon St. Brookline, Mass.
CHICAGO, 53 West Jackson Blvd.
HOUSTON, 2314 Main Street
NEW YORK CITY, Room 1503, 11 Park Place
PHILADELPHIA, 2099 North 63rd Street
PITTSBURGH, Room 512, Bessemer Bldg., 104—6th Street
TULSA, 543 East Apache Street, P. O. Box 6157

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PUMPS FOR INDUSTRY

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Pa., serving later as a sales assistant in the company's Seattle office.

He served from 1940 to 1945 in the Army and from January 1946 until his appointment as pacific coast industrial sales manager in April 1953 he was in various sales capacities in Portland, Ore., and San Francisco.

Cheek

Loomis

WORTHINGTON CORP. has appointed **William C. Cheek** midwest region sales manager. A graduate of North Carolina State College, 1920, where he obtained a B.S. degree in mechanical engineering, Cheek joined Worthington the same year. For three years he served in the Buffalo division Sales department, subsequently serving in the Water Works department at the New York office and in specialized public works and petroleum industries capacities at the Harrison, N. J. division. In 1932 he was assigned to the Chicago office as a general line salesman and in 1937 was appointed assistant manager of the Chicago office. In 1945 Cheek was appointed manager of the Chicago district office, the post he held until his present appointment.

Wise

John H. Loomis replaces Cheek as manager of the Chicago office. Formerly manager of the St. Louis Office, Loomis is a 1942 graduate of Purdue University, where he obtained a B.S. degree in mechanical engineering. He joined Worthington Corp. in 1945, serving as an application engineer in the Buffalo division Compressor Sales department prior to his assignment to the Chicago Office in 1947 as compressor specialist. He served as gen-

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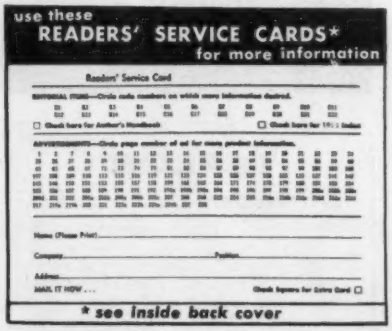

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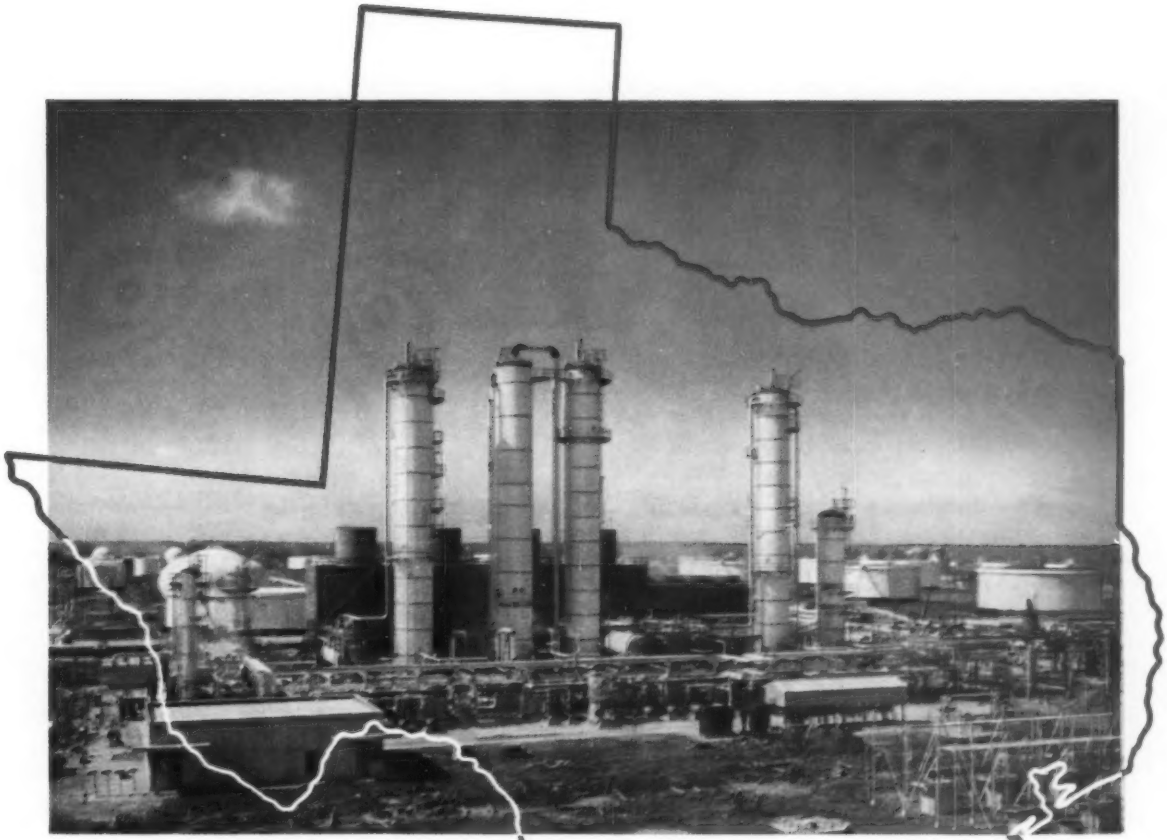

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Four giant towers of the Phillips Petroleum Company's Natural Gas Liquids Fractionating Unit #10A rise over the Texas prairie. It is one of the largest units of its kind in the world.

A unique infra-red and differential refractometer analysis system developed by Phillips provides continuous product and quality control. Stone & Webster Engineering Corporation performed the detailed engineering, design and construction of this unit utilizing process information supplied by Phillips.

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THE CHEMISTRY OF PETROCHEMICAL REACTIONS

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This completely indexed book provides extensive coverage of the basic chemistry of reactions and processing of those products and intermediates popularly classified as petrochemicals. A completely contemporary study, this book is an immediate and valuable reference for anyone engaged in the chemical or refining industry. In addition to technical data, valuable commentaries on end use and market of many significant chemicals are presented in such manner as to make this book a practical working manual. Typical chapter headings include: Production and Reactions of Butadienes, Oxidation of Hydrocarbons, Nitration and Sulfonation of Paraffin and Aromatic Hydrocarbons, Alkylation with Olefins.

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PILOT PLANTS, MODELS, AND SCALE-UP METHODS IN CHEMICAL ENGINEERING

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Here is a useful tool for planning, executing and interpreting small-scale plant experiments. Modern aspects of the field are fully explained and illustrated, including analogue models, reduction of model laws to simple equations, and derivation of dimensionless criteria from fundamental differential equations. Use it to achieve smaller and cheaper pilot plants, larger scale-up factors more dependable test data.

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A comprehensive treatise explaining in easy-to-read language the various problems encountered in refining and finishing petroleum products. Detailed explanations are given on refining of petroleum with chemicals and solvents, use of additives for improving quality of petroleum products, modern testing methods and their interpretations, concept of color (as applied to color of petroleum oils), as well as other theories such as lubrication, viscosity, surface tension, vapor pressure, boiling point, fire and flash point, octane number, etc. The extensive list of thousands of patents on subjects covered and the wealth of referents to the literature are of particular value.

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This guide to the practical application of process design principles in industry brings you the "Key" man's know-how. It is the only book on plant design written from the view-point of the project engineer and in accordance with modern techniques of project organization, planning and execution. Part one of the work outlines the steps and methods of plant design, and part two discusses the business and legal phases of the project. The principles of equipment design and selection used in a process plant are presented in part three. The final portion describes actual construction operations.

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This handy aid can help you provide more accurate, more thorough estimates. It gives you a mine of cost estimation information in concise, easily accessible form. The book supplies a complete breakdown of such components as capital investment and profits, plant location and equipment costs, manufacturing, administrative, and sales expenses, etc. In addition, over 50 easy-to-use graphs offer you time-saving data for making fast estimates of physical plant and equipment costs. And you are given representative prices of more than 1400 chemicals for speedy reference when figuring process costs. Here, indeed, is a valuable aid to preparing more precise cost estimates.

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ENGINEERING USES OF RUBBER

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eral line salesman and in 1955 was appointed manager of the St. Louis office.

Hollis H. Wise is appointed St. Louis district manager. A graduate of Lawrence Tech. where he obtained a B.S. degree in mechanical engineering. Wise joined Worthington in 1938 and was named office supervisor in 1940. He served as Louisville resident salesman and Cincinnati general line salesman. In 1953, Wise was named resident general line salesman out of Indianapolis, the post he held until his present appointment.

CROUSE-HINDS CO., sales engineer **John E. Metzenthin,** was elected president of the Petroleum Electric Supply Association at the annual convention held this year at the Shamrock Hotel, Houston.

Metzenthin previously held the posts of vice-president and general convention chairman in the organization.

BECKMAN INSTRUMENT, INC., has appointed **Lawrence R. Keenen** eastern regional engineering manager for its Systems division. An electrical engineering graduate of Pennsylvania State University, Keenen joined Beckman in November, 1956, following a year as eastern regional sales manager for the Metrotype division of the Hays Corp. From 1950 to 1955, he was a sales engineer for the Brown Instrument division of Minneapolis-Honeywell Regulator Co., covering the New York and New Jersey areas.

L. R. Keenan

Keenan is a member of the Instrument Society of America and the American Institute of Electrical Engineers.

EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Co., has undertaken a new "change-of-duties" program to meet the company's need for men with broader knowledge and experience in all phases of the division's activities.

The first exchange in the new program will involve **J. H. Sanders** and **R. W. Miller. Sanders** is currently the chemical division's Cleveland district manager and has been with the company since 1946. Miller who has been with Eastman since 1948 is presently product manager for all industrial chemicals manufactured by Kodak's Texas Eastman division in Longview, Texas.

In taking over Miller's desk at the company's head office in Kingsport, Tenn., Sanders will assume responsibilities for

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(MESH ENTRAINMENT SEPARATORS)

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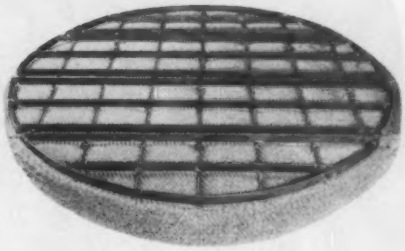
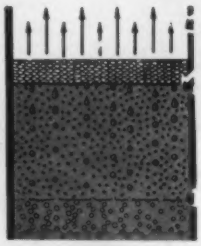
- Improve Product Quality





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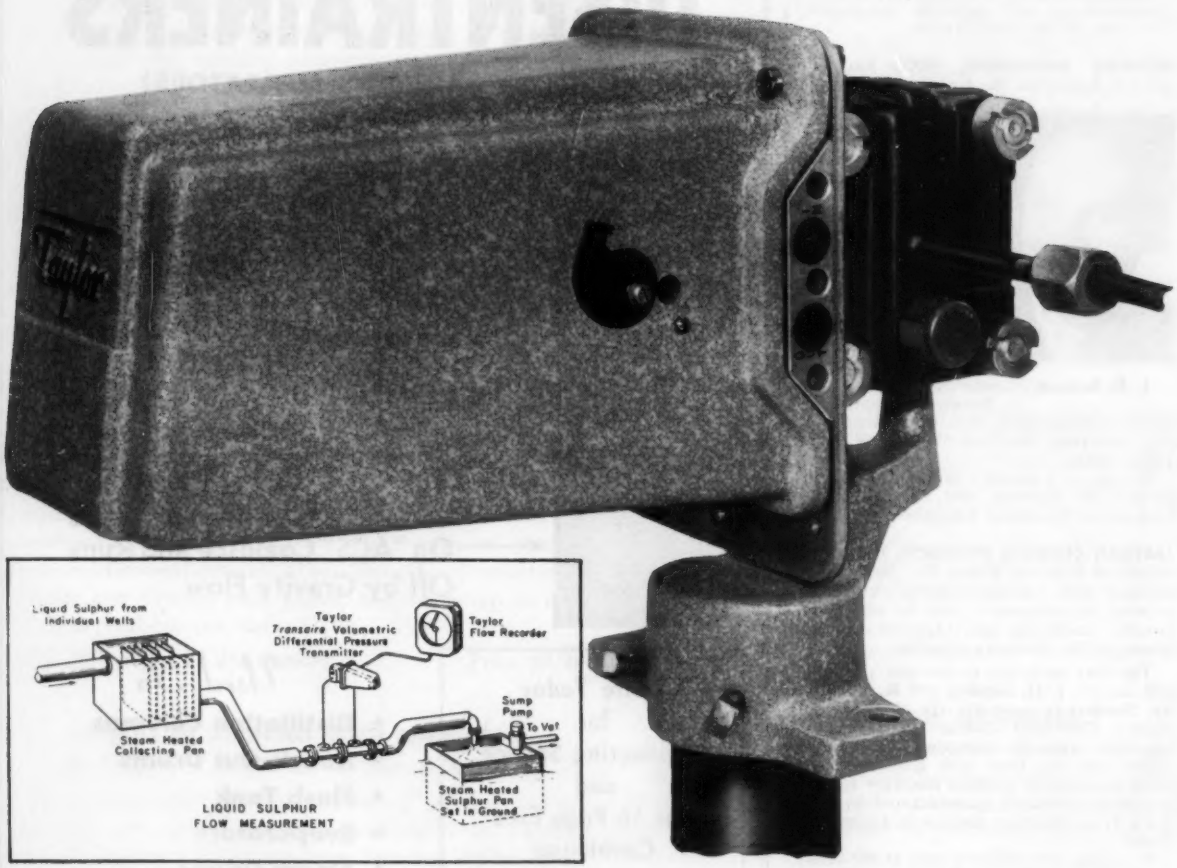

Liquid Sulphur from Individual Wells
Taylor Transaire Volumetric Differential Pressure Transmitter
Taylor Flow Recorder
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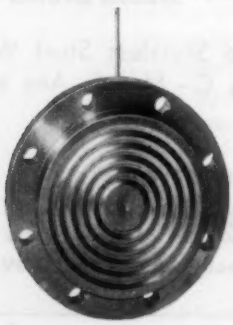
To Vat
Steam Heated Collecting Pan
Steam Heated Sulphur Pan Set in Ground
LIQUID SULPHUR FLOW MEASUREMENT



Type 95 flange, for use with chemical tee. For flow installations where diaphragm is flush with inside of pipe, so that process fluid imparts a scouring action. Also for liquid level applications where diaphragm should be flush mounted.

New Taylor Volumetric Differential Pressure Transmitter

PURGE, SEAL PROBLEMS ECONOMICALLY!

Ideal for these difficult flow and liquid level measurements:

- Slurries
- Corrosive liquids
- Colloidal suspensions
- Fluids that jell when not in motion.

The new Taylor 205T Volumetric Differential Pressure Transmitter is completely isolated from the process material. Thus it never has to be purged of deposited material, never suffers from corrosion. The pressure-sensitive diaphragms may be installed flush with the inside of the pipe or tank in a variety of mountings. The temperature limit is 300° F. at the diaphragms. Pressure limit of the instrument is 1500 lbs., and the system is limited only by the flange rating on the primary side.

This instrument is a modification of the familiar Taylor 333RD differential pressure transmitter, and is just as accurate, sturdy and dependable. For full details about this new instrument, ask your Taylor Field Engineer, or write for **Bulletin 98281.** Taylor Instrument Companies, Rochester, N. Y. and Toronto, Canada.

Taylor Instruments
— MEAN —
ACCURACY FIRST
VISION · INGENUITY · DEPENDABILITY

Wafer type sensing element, for use with Standard 3" ASA flange, where diaphragm need not be flush mounted with process. For example, corrosive flow or liquid level measurement or colloidal suspensions. Standard diaphragm material, for both types, 316 Stainless steel, Hastalloy B, nickel.

For more data on advertised products, use Readers' Service Cards, last page.

your choice of tube expander motor controls . . .
for fast, accurate tube rolling
with **ELLIOTT Tube Expanders**

Expanders available in 4 types for tubes ¼ in. through 3 in.

AIR MAGNETIC CONTROL...

Excellent for precision tube expanding in hazardous locations. Uses new concept of torque control in tube expanding. Two powerful permanent magnets give instantaneous engagement and disengagement between air motor driver and driven expander. Calibrating dial permits exact settings for torque control.

ELECTRIC CONTROL...

Takes guesswork out of tube rolling. A *torque limiting device,* designed for use with any standard tapping motor. A single setting gives same expansion after metal-to-metal contact for entire rolling operation. *Voltage Balancer* eliminates need for voltage regulator. It's compact and easy to operate.

Y7-7

ELLIOTT Company
Lagonda Division, Springfield, Ohio
Headquarters for Tube Cleaners and Expanders

Suppliers . . .

marketing all Texas Eastman chemical products. Miller's move to Cleveland will place him in charge of the division's direct sales in that area.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has named **George W. Hoffmeister** superintendent of the company's new plant at Fall River, Mass. The $300,000 plant will produce a new line of electronic recording and controlling instruments for industrial use. It is being leased by M-H from a group of businessmen-stockholders who financed the plant's construction by popular subscription.

Hoffmeister joined the company's Brown Instruments division in Philadelphia in 1944 as a time study engineer. Prior to his recent appointment he was superintendent of assembly operations in Philadelphia.

BECKMAN INSTRUMENTS, INC., has received a contract to build one of the aluminum industry's first electronic data processing systems for the Aluminum Co. of Canada plant at Kitimat, British Columbia. Aluminum Co. of Canada is the principal operating subsidiary of Aluminium, Ltd., independent Canadian producer.

The system will be designed to monitor cryolite recovery processes for maximum operational efficiency, according to **John F. Bishop,** general manager of the Beckman Systems division at Richmond and Aanaheim, Calif. In full operation next year, the data processing equipment will alert plant operators automatically the instant process variables depart from preset limits.

ARMSTRONG CORK CO. has announced a realignment of responsibilities for its Industrial Insulation Sales and Contract Operations. The changes are a result of the retirement of **Sloane C. Martin,** manager of Low Temperature Insulation sales and assistant manager of Contract Operations. Martin is a veteran of 37 years with the company, having joined Armstrong in 1920 following graduation from Geneva College and military service during World War I.

J. W. Liddell will continue as manager of Contract Operations, being responsible for sales efforts and execution of all Industrial Insulation contracts. He has been assigned the additional responsibility for sales of jobbed and private label brand products. The position of assistant manager of Contract Operations is discontinued.

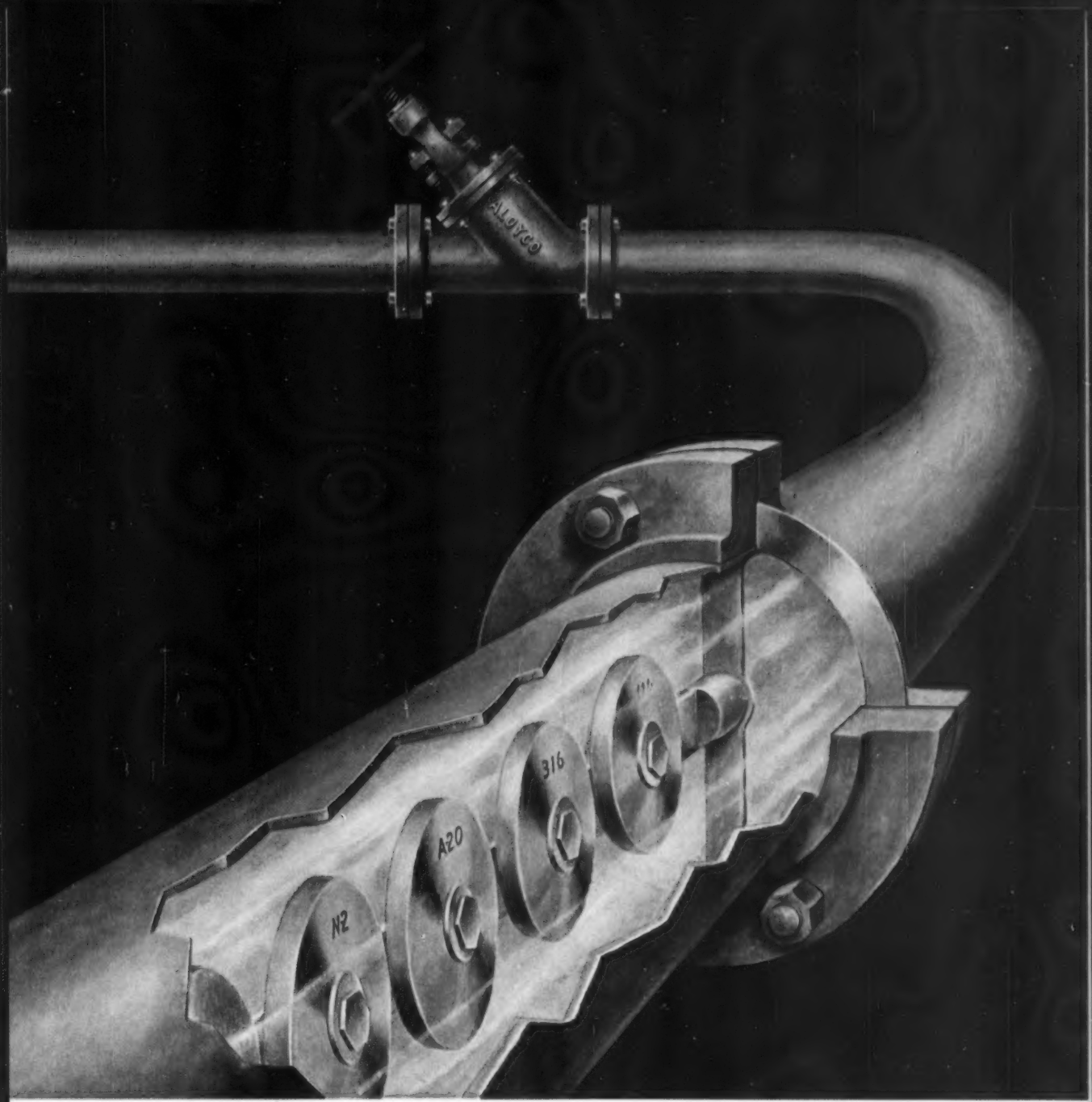
J. P. Sawyer has been appointed manager of Low Temperature Insulation and Insulating Refractories sales. Sawyer previously served as assistant manager of Industrial Insulation sales and manager of Insulating Refractories.

F. S. Donnelly, Jr., who served as manager of Industrial Insulation sales, will become manager of Armaflex and Sundries sales and manager of Market Research and New Product Development.

TRETOLITE CO., division of Petrolite Corp., McPherson, Kan., has named **John Clote** assistant advertising manager of Petrolite Corp., assigned to the St. Louis headquarters.

Clote joined Tretolite Co., in 1952 at McPherson, Kansas. He is a graduate of the University of Missouri School of Jour-

For more data on advertised products, use Readers' Service Cards, last page.



Inside look at Aloyco Corrosion Engineering Service

This is a realistic illustration of an Aloyco line test—as it might be conducted in your plant as a regular part of Aloyco Corrosion Engineering Service.

Whenever there is no 'book solution' to a specific valve problem, we will prepare a test rack carrying a series of alloy specimens (discs above) to be inserted in your process line. Purpose is to pinpoint the alloy that will most efficiently stand up to the specific corrosives under your actual line conditions.

Our sole purpose with the Aloyco Corrosion Engineering Service is to help you successfully solve corrosives-handling problems. Our resources are the metallurgical experience, foundry skills and engineering know-how we have gained in twenty-seven years as the world's largest specialist in Stainless Steel Valves.

Bring your corrosion problem to Alloy Steel Products Company, 1301 West Elizabeth Avenue, Linden, New Jersey. 7.2

ALLOY STEEL PRODUCTS COMPANY

Today, more than ever before in history, oil is a vital commodity of freedom. And the tanker that carries oil is truly a citadel of freedom.

Above, you see such a vessel . . . one of several new Cities Service tankers incorporating the latest in design, efficiency and speed. And Cities Service is building still newer tankers to keep not abreast, but ahead of the constantly growing demand for these magnificent work horses of the petroleum industry.

These ships are designed to carry oil to ports all over the world. Designed to transport twice the oil of former tankers . . . with each one capable of carrying enough fuel oil to heat 15,500 homes for a year! And, designed to load, travel and unload at amazing speeds, too. For today, it is clear that speed of delivery can be as important as the oil cargo itself.

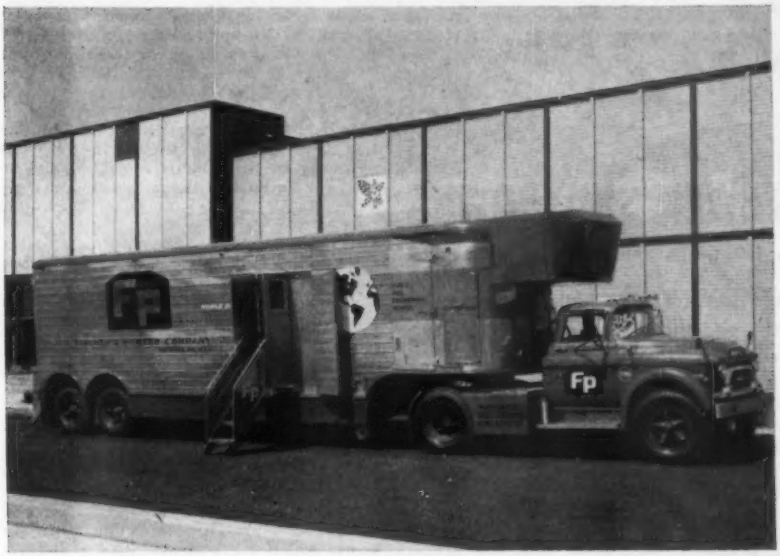
But, before this mighty fleet can travel at all, its cargo of oil must be found and produced. Thus, in the arctic tundra, in deserts, bayous, offshore waters, and oil fertile valleys throughout the world, Cities Service is now pushing forward the greatest oil search in its history . . . planning to find more oil in the next few years than in its entire history of nearly a half-century!

Finding and delivering more oil is part of a giant expansion program which will enable Cities Service to continue contributing toward a better world for all.

CITIES SERVICE

nalism, and served as district editor for the Oil and Gas Journal at Tulsa and later at Houston.

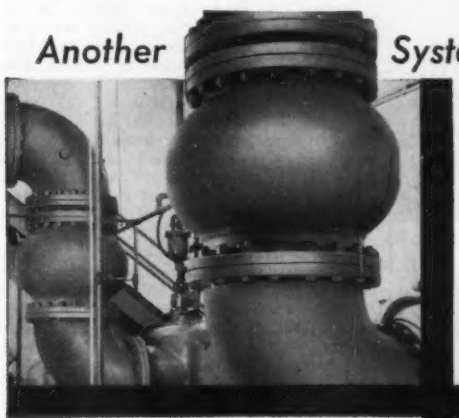
Suppliers . . .



FISCHER & PORTER CO., is sending a mobile exhibit of its products on a swing around the country.

The exhibit is housed in a specially constructed stainless steel trailer, completely equipped to give-on-the-spot operating demonstrations of dozens of F&P's products before customer groups, technical schools and universities and at meetings of engineering societies.

The first public appearance of the exhibit was at the American Water Works Association convention held in Atlantic City, N. J., in May of this year. A few



Another System Made

SAFE FROM WATER HAMMER

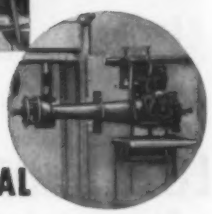
Here is protection against damage from surge pressures . . . the means to eliminate resulting water hammer. They operate instantly when flow reversal starts or when flow is zero. Write for descriptive Bulletins.

WILLIAMS-HAGER Silent CHECK VALVES

Write for Bulletins No. 654 on the Valves; No. 851 on Cause, Effect and Control of Water Hammer

THE WILLIAMS GAUGE CO., INC.
151 STANWIX STREET
2 GATEWAY CENTER PITTSBURGH 22, PA.
Our 71st Year • 1886-1957

VERTICAL



OR HORIZONTAL

many more hours on stream without forced shutdown with NATIONAL AIROIL

OIL-GAS TANDEM COMBUSTION UNITS

Exclusively for vertical firing, the new National Airoil VERTICAL Tandem Block Units retain all the features of our regular horizontal Tandem Units . . . plus: special, precast refractory shapes for easier, cost-saving vertical installation and maintenance; secondary air inlet louvres for positive control of vertical flame pattern; and, all steel duplex detaching gear which enables swift, simple vertical burner changeover.

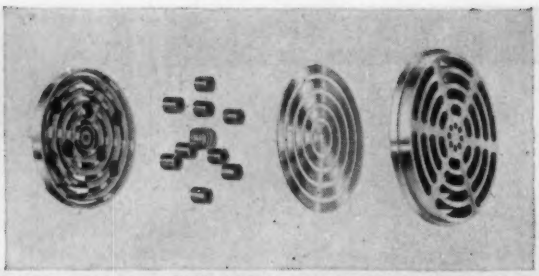
VERTICAL and HORIZONTAL Tandem Units hold air in the combustion zone until fuel and heated air are thoroughly mixed. This means that ignition takes place in a hot zone; the result: high fuel economy through more rapid combustion with a minimum of excess air. NATIONAL AIROIL's patented Tandem Combustion Units allow secondary air to be easily and accurately controlled. By adjusting air control louvres, flame can be shaped to radiate heat uniformly without tube impingement.

The VERTICAL or HORIZONTAL Tandem Unit is always fired with NATIONAL AIROIL Combination Oil and Gas Burners . . . has a high turndown ratio with a steady flame temperature using either fuel oil or gas. With the TANDEM UNIT's clean flame, a cold furnace can be brought to full capacity in a short time.

"Many, many more hours on stream, without shutdown" . . . yes, YOU will realize higher profits from YOUR heaters when NATIONAL AIROIL VERTICAL or HORIZONTAL Tandem Units are specified. Our new Bulletin 498 is yours for the asking.

CHEMICAL-PETROLEUM DIVISION
NATIONAL AIROIL BURNER CO., INC.
1254 EAST SEDGLEY AVE., PHILA. 34, PA.
Southwestern Division
2512 South Boulevard, Houston 6, Texas
INDUSTRIAL OIL BURNERS, GAS BURNERS, AND FURNACE EQUIPMENT

VOSS VALVES
in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS
for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

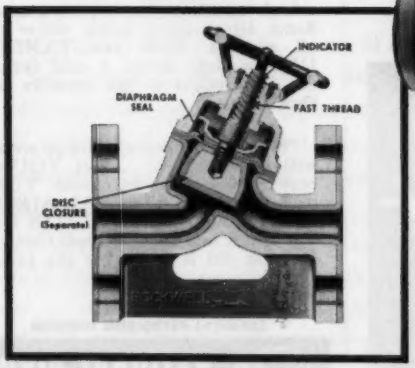
VOSS VALVES are made to specification, machined from solid stock (not cast) — VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.
J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

Best by Far – for Low Cost Corrosion, Abrasion, Vacuum and General Service

W. S. ROCKWELL
DIAPHRAGM VALVE



- No packing gland to leak. Mechanism not exposed.
- Oversized ports; high capacity; low pressure drop. Largest capacity of any diaphragm type valve.
- Self-draining in horizontal position.
- Closure is by rubber disc.
- Lower handwheel torque and fewer turns to close.
- Automatic control available.
- Body of any metal or with any lining.
- Sizes ½" to 6".

Always closes Diaphragm seals mechanism
Write for Bulletin

W. S. ROCKWELL COMPANY — 2367 Eliot St., Fairfield, Conn.

Suppliers . . .

weeks later the trailer appeared at Lake Placid, N. Y., at a meeting of the Technical Association of the Pulp and Paper Industry. From New York state the exhibit headed westward and is expected to reach the northwestern coast in late October. Turning southward, the trailer will tour California, then make its way eastward by a southern route. Arrival at Fischer & Porter's home office in Hatboro, Pa., is planned for June, 1958.

OAKITE PRODUCTS, INC., has announced the assignment of two technical service representatives.

Donald O. Mundale, the company's representative in Asheville, N. C., has been transferred to Marion, Ohio. **James E. Davenport,** a graduate in engineering from the United States Naval Academy, has been assigned to Rocky Mount, N. C.

Davenport recently completed an eight-week training program at Oakite's New York headquarters, and in the field.

YUBA CONSOLIDATED INDUSTRIES, INC., San Francisco, Calif., recently announced three promotions in connection with the newly added Yuba Heat Transfer division at Honesdale, Pa., formerly The Heat Exchanger division of The Lummus Co.

George Evans, Teaneck, N. J., formerly sales manager, has been elevated to assistant to the vice president in charge of sales for Yuba Consolidated Industries, Inc., and will have his headquarters in New York. Evans will continue his activity with the Heat Transfer division, and will assist John Martin on the corporate level.

Robert A. Beck, West Orange, N. J., formerly assistant to the general manager, has been appointed general sales manager for the division. Beck has been with The Heat Exchanger division for nineteen years.

Robert H. Shaw, who has been a senior sales engineer, has been promoted to sales manager, Eastern division of the Yuba Heat Transfer division. Shaw lives in Westfield, N. J., and has been with the company for six years.

A. O. SMITH CORP. has given **H. D. Barnes,** manager of defense products, the additional assignment of managing the company's Atomic Equipment section. Barnes will coordinate research and engineering activities for the manufacture of atomic energy equipment.

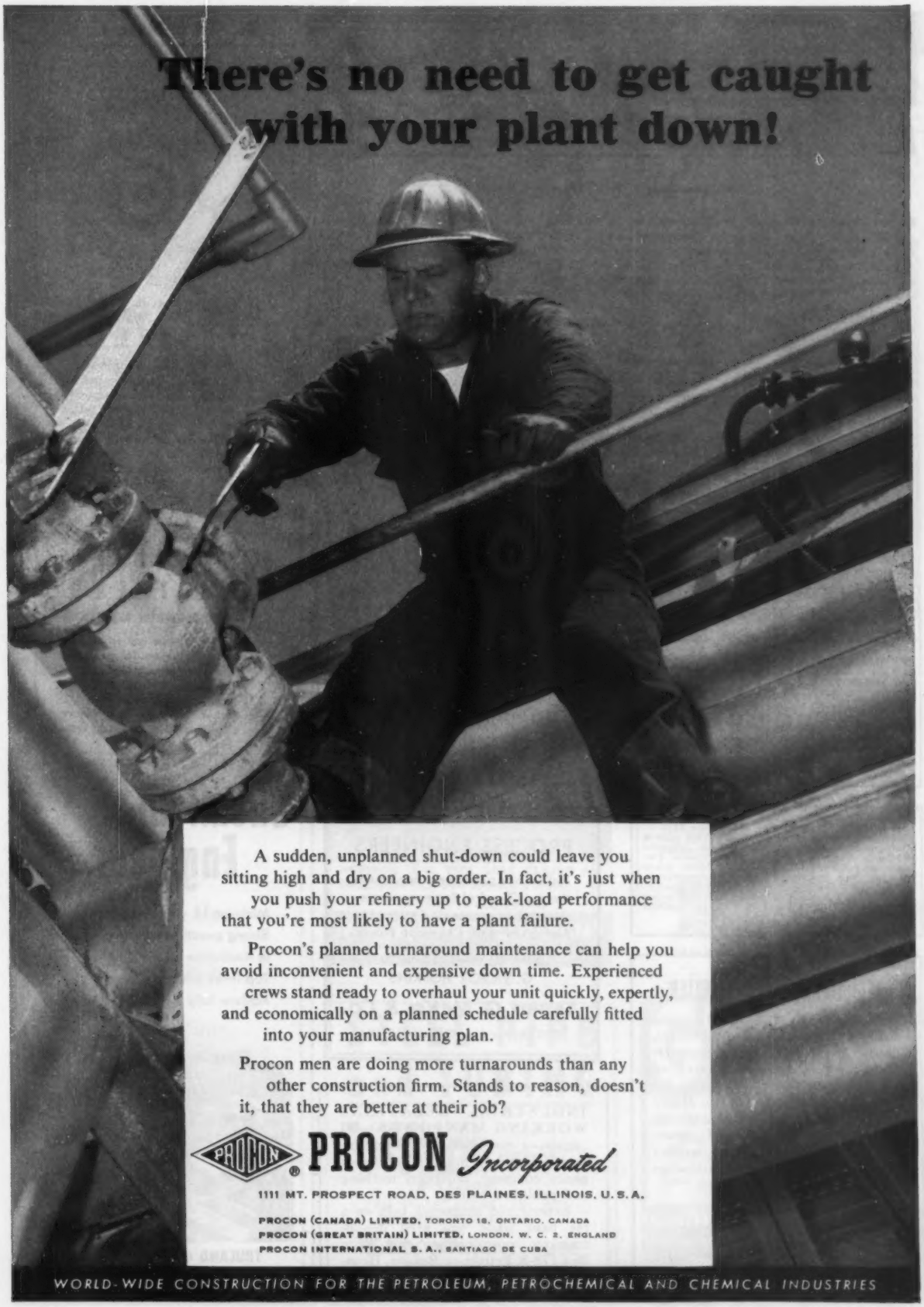
Deaths

ARTHUR DOOLEY died in Beaumont, Texas. As founder and president of Arthur Dooley and Son, he was active in business until his death. Dooley was well known by oil and gas men in Texas and Louisiana.

JAMES EMMETT, JR., 50, vice president in charge of sales for Jas. P. Marsh Corp., Skokie, Ill., died of a heart attack. Death occurred while he was en route to his home in Hinsdale, Ill., following a business trip to Texas.

IRVING W. REYNOLDS, 77, vice president of The Foxboro Co., died of a heart attack at his home in Foxboro, Mass. Reynolds joined Foxboro in 1908, the year the company was founded.

For more data on advertised products, use Readers' Service Cards, last page.



A sudden, unplanned shut-down could leave you sitting high and dry on a big order. In fact, it's just when you push your refinery up to peak-load performance that you're most likely to have a plant failure.

Procon's planned turnaround maintenance can help you avoid inconvenient and expensive down time. Experienced crews stand ready to overhaul your unit quickly, expertly, and economically on a planned schedule carefully fitted into your manufacturing plan.

Procon men are doing more turnarounds than any other construction firm. Stands to reason, doesn't it, that they are better at their job?

PROCON *Incorporated*

1111 MT. PROSPECT ROAD, DES PLAINES, ILLINOIS, U.S.A.

PROCON (CANADA) LIMITED, TORONTO 18, ONTARIO, CANADA
PROCON (GREAT BRITAIN) LIMITED, LONDON, W. C. 2, ENGLAND
PROCON INTERNATIONAL S. A., SANTIAGO DE CUBA

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL AND CHEMICAL INDUSTRIES

For more data on advertised products, use Readers' Service Cards, last page.

PETROLEUM REFINER

Classified Ads

Petroleum Refiner New Classified Rates

RATES: **Regular Classified** (undisplayed) set in this size type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border, $12.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * * *

HELP WANTED

CHEMICAL ENGINEERS
PROCESS ENGINEERING

Young men with advanced degrees in chemical engineering or at least three years' experience in process design of oil refining or chemical manufacturing facilities. Opportunities directly concerned with evaluation of research projects in the petroleum and chemical fields and design of new process units for Shell Oil Company and Shell Chemical Corporation. Located in the San Francisco Bay Area. Write giving education, experience, and personal history to Employment Supervisor.

SHELL DEVELOPMENT COMPANY
Emeryville 8, California

CHEMICAL ENGINEER

Excellent opportunity with a West Coast Independent Oil Company (San Joaquin Valley). Refinery Experience, Process Design and Operation essential. Must have Engineering Degree. Salary Commensurate with ability and experience. Reply outlining personal history, photograph and work background. Box 277-R, PETROLEUM REFINER, Houston, Texas.

TECHNICAL ANALYST-WRITER

Broad-range job of technical writing and editing, including brochures, press releases, technical papers, reports, and monthly summary of petroleum-refining developments for high-level outside circulation. Desire engineer or chemist with knowledge of petroleum-refining and petrochemicals fields, plus prior writing experience. For more particulars send name and address to:

Personnel Manager
ETHYL CORPORATION
1600 W. Eight Mile Road
Ferndale 20, Detroit, Michigan

PROCESS ENGINEERS

McKee has permanent opportunities for Chemical Engineers experienced in process design for Petroleum and Chemical Plants.

Send detailed resume to
G. VICTOR HOPKINS

ARTHUR G. McKEE & Co.
2300 Chester Ave., Cleveland 1, Ohio

INDUSTRIAL RELATIONS WORKING MANPOWER—all phases—a combination of sound industrial relations practice in a 'labor peace' company, university teaching and published writing.

Experienced temporary help on a fee basis while you need it—domestic or overseas assignments. Write Box 278-R Petroleum Refiner, Houston, Texas for details.

HELP WANTED

CHEMICAL ENGINEERS

Growing refining and petro-chemical company, reorganizing technical division, needs chemical engineers for technical service and process design and development. Experience desired but not necessary. Address inquiries to P. D. Mook, Cosden Petroleum Corporation, Box 1311, Big Spring, Texas. Representative will be at AICHE in Galveston, October 18.

CHEMICAL ENGINEER

with computer experience

. . . to organize and set up computer applications for growing refining and petro-chemical company. Experience, imagination, and aggressiveness desired. Address C. E. Bolton, Cosden Petroleum Corporation, Box 1311, Big Spring, Texas.

Chemical Engineer

Minimum 10 years experience.
Strong practical background in distillation operations.
Top level position in ultra-modern fully instrumented plant.

TRULAND CHEMICAL CO., Inc.
EAST RUTHERFORD, N. J.
Division of THE TRUBEK LABORATORIES, Inc.

FOR SALE

Save on Your INDUSTRIAL TRACK

FOSTER QUALITY

FULLY GUARANTEED

RELAYING RAILS

Handle more cars better—cost less to install and maintain. Foster stocks all Rail Sections 12# thru 175#, Switch Material and Track Accessories.

SEND FOR CATALOGS

RAILS · TRACK EQUIPMENT · PIPE · PILING

L B FOSTER CO.

PITTSBURGH 30 • NEW YORK 7 • CHICAGO 4
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If You Want

Fast

Results . . .

. be

Sure

to

Use

Petroleum

Refiner

Classified Ads

They don't cost,

they pay.

BECKMAN INSTRUMENTS, INC., through its Systems division, has received a contract from North American Aviation, Inc., for an electronic data handling system to speed wind tunnel testing of supersonic aircraft.

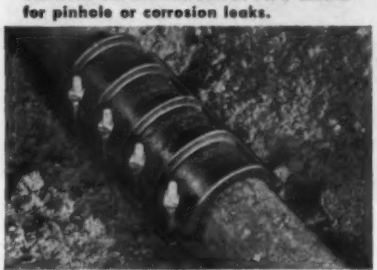
Division manager **John F. Bishop** said the system will reduce by 95 percent the time required to prepare test data for engineering analysis, pinpointing specific test areas as information is recorded at the rate of hundreds of digits per second.

Bishop said the system employs an analog computer to visually map test data as it is recorded numerically on magnetic tape. With the analog map as a guide, engineers can quickly monitor pertinent test areas without waiting for final reduction of all the information on the tape record.

TO REPAIR PIPE LEAKS—QUICKLY, PERMANENTLY

ANY PRESSURE — ANY TEMPERATURE

SKINNER-SEAL EMERGENCY PIPE CLAMP for pinhole or corrosion leaks.



SKINNER-SEAL PIPE LINE CLAMP for long splits and bad corrosion leaks.

In stock—all supply stores

M. B. SKINNER COMPANY
SOUTH BEND 21, INDIANA, U. S. A.

STEEL PIPE and TUBING

- CARBON MOLY
- CHROME MOLY
- VALVES AND FITTINGS
- STAINLESS
- CARBON

ALL SPECIFICATIONS – ANY SIZE
Write for Stock List

MIDCONTINENT TUBE SERVICE, Inc.
2120 Lee St., Evanston, Ill., Davis 8-4030

Suppliers . . .

THE ENJAY CO. INC., New York, has appointed **George Strutz** sales representative in its Akron, Ohio, office. Strutz was formerly development engineer for the Columbia Southern Chemical Corp., Barberton, Ohio. He received a B.S. degree in chemical engineering from Fenn College and is a member of AIChE and ACS.

BARRETT automatic
Filling and Crimping Equipment
for handling greases and other viscous fluids.

- No operator required.
- 100% air operated.

Fills, seals, stamps and counts lug cover pails. Output of 15 pails per minute. Write for details on installation to meet your requirements.

BARRETT
Manufacturing Co.
P. O. Box 8096, Houston 4, Texas

REFRACTORY HAYDITE
Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
We sell direct to you.

CONSTRUCTION MATERIALS
CARTER-WATERS
KANSAS CITY MISSOURI

2440 Pennway Phone GRand 1-2570

GUNITE
Since 1915
CONCRETE
SAND AND CEMENT
"Placed by Air"

We have the equipment, personnel and experience to complete GUNITE work anywhere.

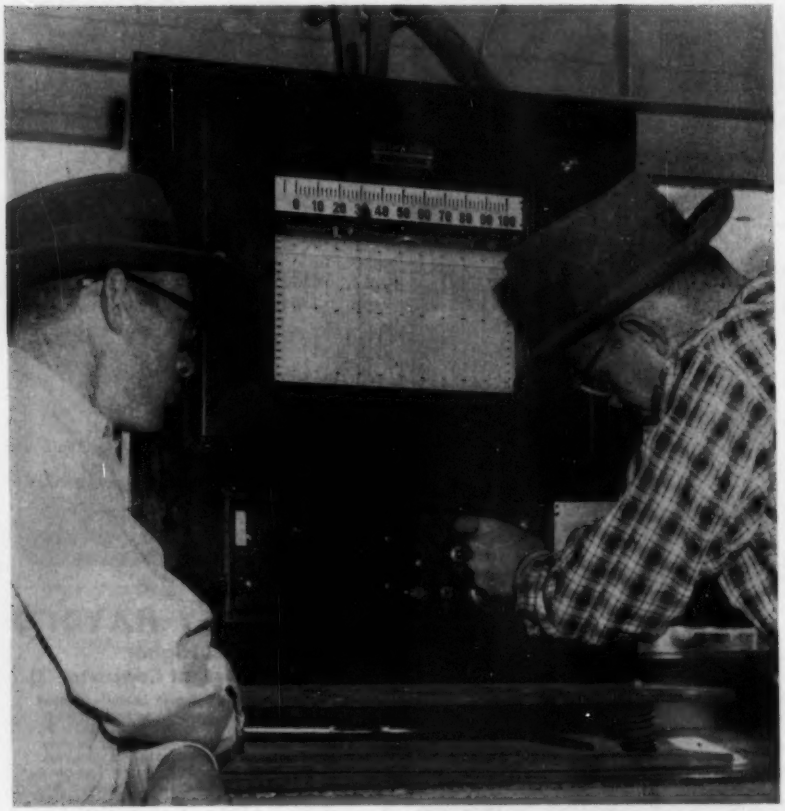
Send for specifications and bulletins

GUNITE CONCRETE & CONST. CO.
1301 WOODSWETHER RD., KANSAS CITY 5, MO.
2016 W. WALNUT ST., CHICAGO 12, ILL.
1004 MARKET ST., ST. LOUIS 1, MO.
3206 HOUSTON AVE., HOUSTON 9, TEXAS
1136 W. ORANGETHORPE, FULLERTON, CALIF.
Milwaukee—Twin Cities—Denver—New Orleans

For more data on advertised products, use Readers' Service Cards, last page.

What's New in Equipment . . .

. . . and Manufacturers Literature



Infrared Gas Analysis Diagnoses Troubles

Instant diagnosis of operating difficulties and rapid adjustment during plant startup are made possible by infrared analysis at the Mississippi Chemical Corp.'s Yazoo City, Miss., plant.

The instrumentation, M-S-A Lira, checks on gas purification operations in the ammonia synthesis-gas preparation facility by monitoring the carbon monoxide, carbon dioxide and methane content of hydrogen-nitrogen make-up streams.

The infrared analyzer is a non-dispersive type infrared absorption comparison instrument. Two similar Nichrome filaments are the separate radiation sources for the "test" and "reference" beams. A motorized reciprocating shutter, or "beam-chopper," alternately interrupts these in such a way that superimposing the two "blinking" beams would result in a single steady beam.

The stream sample flows through a stainless steel cell in the optical path of the "test" beam; a comparison cell in the other beam path contains a pure comparison gas, usually nitrogen.

After passing through the sample and comparison cell, the two beams unite in a beam combiner which focuses on a pneumatic microphone-condenser. The result is an electrical signal of amplitude proportional to the difference in infrared absorption between the test sample and the reference standard. This signal, on amplification, actuates a recorder calibrated to read directly the test sample components.

In the Lira setup at Mississippi Chemical, a sampling manifold arrangement allows any one of six separate gas streams to be checked for impurity content. Normal practice is to record continuously the methane concentration in two of the six streams, alternating from one stream to the other every four hours. When desired, the other impurities can be determined by the same type of instrumentation with minor internal modifications. Mine Safety Appliance Co.

Circle E1 green card, last page

Self-Adhering Industrial Markers Described

To help engineering and plant maintenance departments in permanently identifying chemical flow fuel systems piping, ducts, conduits and other systems, a complete catalog outlining printed industrial markers, its legends and codes that give positive identification for the above systems, is now available.

Tel-A-Pipe self-adhering markers are furnished on easily handled dispenser cards for instant application. Saves hours of labor by eliminating messy painting and costly time consuming stenciling. Tel-A-Pipe temperature ranges from —300 F. to +300 F. Also available in vinyl, glass-cloth, aluminum-foil, and other materials desired by customer's specification. Westline Products division, Western Lithograph Co. **Circle E2 green card, last page**

Catalog Describes New Auto-Sampling Device

A catalog on an auto-sampling device which continuously measures and records both the temperature and the temperature-compensated viscosity of liquids flowing in process piping, has just been published. The Viscorater system is particularly appropriate to the petroleum refining industry.

Principal advantages of the Viscorator, in addition to continuous measurement, are rapid response and the elimination of cumbersome temperature baths. Capacity of the Viscorator is such that flow rates ranging from 4 to 18 gmp and viscosity ranges up to 2500 SSU may be sampled. Fischer & Porter Co.

Circle E3 green card, last page

Round Gasket Cutter Is Also Used To Scribe

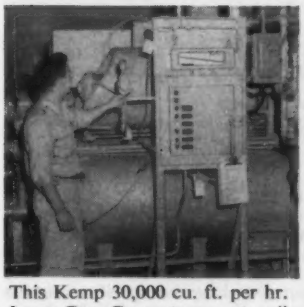
A new bulletin describing the latest type gasket cutter has just been published. The tool is used to cut round gaskets from asbestos, rubber, fibre or cork sheets can also be used for prescision scribing and layout work.

The gasket cutter, known as the 'B" set, is a finely made tool featuring a hexagonal-shaped bar providing a six-sided face on which to mount the knife and point holders. This bar assures a smooth, positive gripping surface for the holders. The tool is adjustable to cut gaskets 1¼

Interior of Kemp Generator in action

Burned up by inert gas costs?

Come to Kemp



This Kemp 30,000 cu. ft. per hr. Inert Gas Generator meets all purging and blanketing needs at Gulf Oil's Port Arthur plant. Complete safety is assured with the more-than-adequate supply provided by the generator. Refineries everywhere depend on Kemp equipment.

Kemp Inert Gas Generators end the trouble and expense of bottled gas, provide a highly flexible source of supply at a fraction of the cost. With Kemp generators in your operation, you can make liberal use of inerts . . . apply them to the improvement of many other operations. There are Kemp units to manufacture inerts in any quantity, for any application.

Kemp equipment is dependable. You get rugged design, simplicity of operation, and almost complete elimination of maintenance. Each unit is completely protected with safety devices. The heart of the generator is the famous Kemp Carburetor, for precise control of inert quality, regardless of system demands.

Kemp produced inerts belong in your plant . . . for blanketing, purging, and protective uses . . . agitation of batches during cooking . . . conveying combustibles and controlling reactions.

For new installations or modernization programs, call in your Kemp Representative. Or write us for Bulletin I-10. The C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore 2, Md.

Kemp Convection Dryers

Kemp Immersion Melting Pots

KEMP OF BALTIMORE

Kemp Industrial Carburetors

Kemp Oriad Dryers

AIRETOOL

St IN TUBE MAINTENANCE EQUIPMENT

For over 27 years, Airetool Manufacturing Company has pioneered in the research, design, development and manufacture of tools and air-powered motors for use in constructing and maintaining all types of tubular equipment. Today, many Airetool developments are accepted as "standard" methods by those in the tubular construction and maintenance industries.

As refineries and industries grow larger and more complex, tube maintenance problems increase. Airetool designers and engineers combine modern research and planning methods with quality materials and precision construction so that today's maintenance problems need not be handled by yesterday's methods.

AIRETOOL tube construction and maintenance equipment is your assurance of outstanding dependability and performance.

TUBE CLEANERS — Rugged, fast cutting, easily remove hard scale and deposits. Air driven motors in wide range of sizes and speeds. P-type cleaner head illustrated, many others available.

CONDENSER CLEANERS — Powerful, fast, and dependable. Air driven motors muffled for quiet operation. Built-in flushing system keeps cleaner heads cool, removes cuttings.

AUTOMATIC TUBE EXPANSION CONTROL SYSTEM — Accurately rolls tube joints to correct, preset tightness. The "standard" for efficient tube rolling.

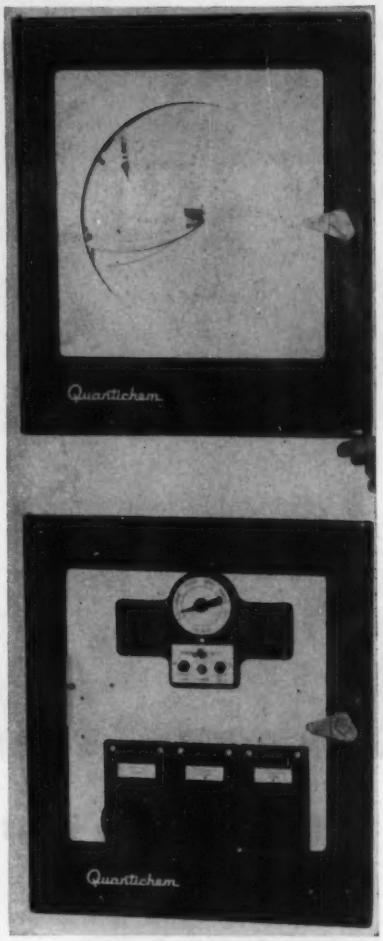
These are just a few of the many Airetool products available for your use. Remember . . . there's an AIRETOOL tube cleaner and tube expander for every type of tubular construction. Write for free, illustrated literature. Ask for Bulletin No. 60.

BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge
REPRESENTATIVES: in principal cities of U. S., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii
EUROPEAN PLANT: Vlaardingen, The Netherlands
CANADIAN PLANT: Brantford, Ontario

New Equipment . . .

inches to 22¼ inches outside diameters. Center point and knife holders can be mounted on a bar for cutting larger gaskets. Samples of four widely used sheet packings are included with the cutter sets. The Garlock Packing Co.

Circle E4 green card, last page



Instrument Gives Continuous Analysis of Water Hardness

Backed by more than three years of research and field studies, new instruments for continuous analysis of water for total hardness or silica concentration, is announced. Each analysis is on a fixed time cycle with the results recorded on a separate unit that may include alarms or control devices.

The analyses are based on the effects silica or hardness-causing calcium and magnesium ions have on specific reagents which change the amount of light that a given volume of sample solution will absorb or transmit. The difference in the amount of transmitted light through a zero cell and a test cell is measured photoelectrically, and because the difference is proportional to the concentration of silica or hardness, the instruments are calibrated to read in units of concentration.

The silica analyzer has a range of 0

Corrosioneering News

Quick facts about services and equipment available to help you reduce corrosion and processing costs.

Published by The Pfaudler Co., Rochester, N.Y., U.S.A.

Now, fill 600 quarts of lube oil a minute with Pfaudler's NEW RPL-36 filler

Regardless of viscosity, you can fill 600 quart cans of lube oil a minute with the RPL-36 filler — fastest on the market.

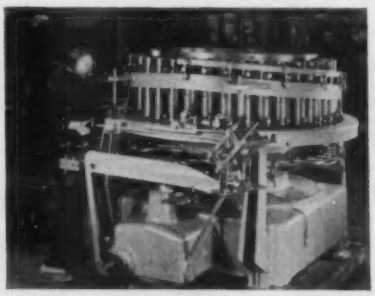
At this speed, you get filling accuracy within ± .1 fluid oz. with no spill-over to stain your cartons.

You can easily make filling adjustments while the machine is running —from either of two points—one on each side.

Empties won't jam up when you move into high-speed operation because an infeed screw provides uniform acceleration. No matter how fast the machine is running, if there's no can under the filling pot—there's no fill.

The RPL-36 gives you straight-line discharge. And the synchronized transfer of filled containers to your closing machine is engineered to fit your plant.

For smooth operation and long life, all filler drive mechanisms are mounted on ball and roller bearings.



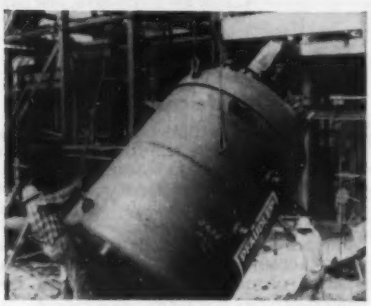
All gears are enclosed in an oil bath for positive, continuous lubrication.

Get full information on Pfaudler's *new* RPL-36 oil lube filler.

Check coupon for Bulletin 964.

How 15 men put Pfaudler equipment "on stream" and keep it in prime condition

The man hurried up the ramp into an airplane. As soon as he landed, a taxi rushed him to a train. Another taxi sped him to a ship. Ashore, still another taxi carried him to his destination: a Pfaudler customer's plant.



Supervision of installation crews at the plant site. Pfaudler field servicemen save time, often avoid equipment damage, and assure operational efficiency. To help get equipment into place quickly, lifting lugs are conveniently located on all Pfaudler vessels.

This performance, although out of the ordinary, illustrates well the first duty of our fifteen field service supervisors: when there's trouble, get there fast; downtime costs money.

The eldest of this group has been servicing Pfaudler equipment for 45 years. The "youngest," relatively new with Pfaudler, has 20 years' experience in chemical processing.

That's the second mark of these men: experience and ability: ability to hire and direct a crew of riggers, ability to actually repair equipment in the field.

Recently, in an unusual case, a customer's plant was badly damaged by fire. A Pfaudler tank needed extensive repairs, so the servicemen removed the tank from the line, shipped it to our plant, and reinstalled it at the customer's plant—all within a single week.

That's another dimension of the job: making quick decisions and knowing when to request assistance from the production, research, and engineering men in the home plant.

The key words for the whole program are customer service—service in helping to get a plant started, routine service to assure long use life, and prompt repair service to keep downtime to an absolute minimum.

Users of Pfaudler process equipment know that this Field Service Department is itself just a part of our complete program which also includes frequent seminars on corrosioneering, maintenance classes, some of which are held in customer plants, a Customer Advisory Board to review new designs, and complete laboratory pretesting facilities.

Would two-week delivery help you decide where to buy a heat exchanger?

Off-the-shelf delivery by Pfaudler can solve many of your heat-transfer problems in just two weeks.

This stocking program applies to tube side 316 stainless steel heat exchangers with carbon steel shell in single- and double-pass, fixed tube sheet design. Capacities include 56, 104, 149, 216 and 316 sq. ft. Other standard FTS sizes up to 20″ shell diameters are quickly assembled to your specifications in four to six weeks.

Pfaudler also stockpiles a complete line of flexible standard *components*, permitting quick delivery on many sizes of packed floating head, internal floating head and "U" bundle design types.

If your needs can't be met with standard stainless steel units, Pfaudler offers heat exchangers of many different alloys. Included are nickel, Inconel, monel, titanium, zirconium, Hastelloy, karbate and combination units of karbate and glassed steel, or glassed steel and alloy construction.

Call on Pfaudler's design department to help you solve your heat transfer problems. They'll be glad to give you the benefit of years of experience in the process industries, not only with heat exchangers but other integrated Pfaudler process equipment.

New Heat Exchanger Bulletin

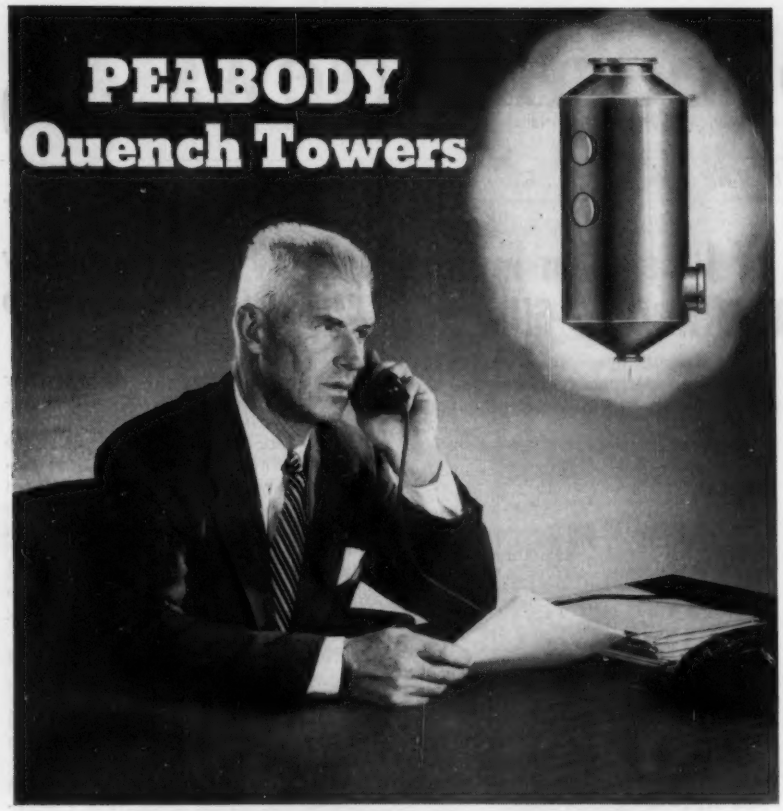
Bulletin 949, just off the press, contains 28 pages of informative data on Pfaudler's flexible standard and custom-built heat exchangers including applications, types available, design specifications and operating characteristics. Check coupon.

THE PFAUDLER CO.
Dept. PR-107, Rochester 3, N.Y.

Send me bulletins checked:
☐ Bulletin 964, RPL-36 Lube Filler;
☐ Bulletin 949, Heat exchangers; ☐ Bulletin 947, Pfaudler Buyer's Guide.

Name..... Title.....
Company.....
Address.....
City..... Zone..... State.....

For more data on advertised products, use Readers' Service Cards, last page.



are still the answer!

★ *They quench, cool and clean gas—*

A large oil company in Texas uses a Peabody direct-contact quench tower in its ethylene plant. Cracked gas enters the tower at 600° F. and clean gas, cooled to 100° F., leaves at the rate of 103,500 C.F.M.

The Peabody Tower is adaptable to a wide variety of flow cycles. It quenches and cools high temperature gas from reforming furnaces or synthesis gas generators, and *simultaneously* removes particulate matter, such as tars and carbonaceous material.

This compact, low-pressure-drop unit provides minimum usage of low-pressure process water. It brings hot gas and coolant into intimate contact for positive mass transfer – gas can be cooled to within a few degrees of liquid inlet temperature. Outlet gas temperature and general performance can be held constant over a wide range of flow rates.

If you want clean, dry, cool gas, use a Peabody Tower.

PEABODY ENGINEERING CORPORATION

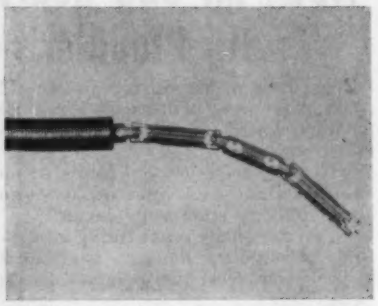
232 MADISON AVENUE, NEW YORK 16, N. Y.

OFFICES IN PRINCIPAL CITIES

PEABODY LIMITED • LONDON, S.W. 1, ENGLAND 7-101

New Equipment . . .

to 0.05 ppm. The standard ranges for the total hardness analyzers are 0-3 and 0-5 ppm with a sensitivity of 0.03 and 0.05 ppm respectively, calibrated as calcium carbonate. Other ranges are available to meet special applications. Milton Roy Co. **Circle E5 green card, last page**



Remote Control for Hard To Reach Hand Valves

A new flexible shaft with equal torque in both directions, unlimited length and equal flexibility in all sizes from three-eighths inch to three inches diameters, suitable for remote controls and power drives, is now available.

The links consist of trunnion blocks and two half links fastened together with screws or rivets. Cover materials are available in a variety of materials including armored neoprene hose, non-metallic hose or semi-rigid tube. End fittings are available to meet given requirements. Minimum link length is three times the diameter and various link lengths can be combined in one shaft using long links for straight runs.

Torque ratings for manual torsional movement are 50 in. lbs. for ⅜ inch shaft, 200 in. lbs. for ½ inch shaft and 2500 in. lbs. for 1¼ inch shaft. For motor drives at 1750 RPM ⅛ HP requires ⅜ inch shaft, ⅓ HP requires ½ inch shaft and 1 HP requires ¾ inch shaft. Clark Flexible Link Shaft Co.

Circle E6 green card, last page

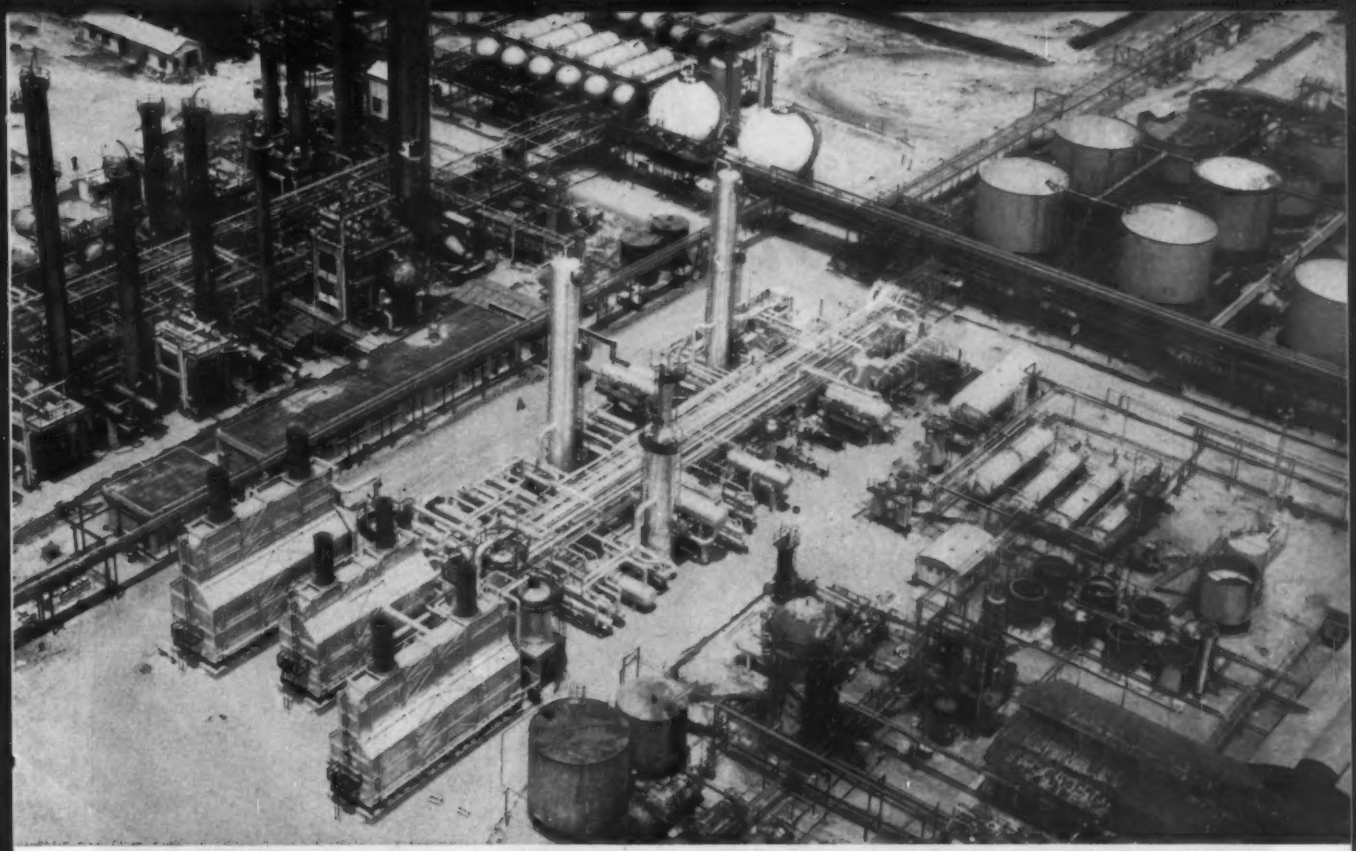
Bulletin Describes Heavy Duty Centrifugal Pumps

A new 16-page bulletin featuring Class GT general-purpose, centrifugal pumps is now available. GT pumps are built in six basic sizes ranging in capacities from 100 to 3500 gpm, pressures of 450 psi, heads to 1100 feet and temperatures at 300 F. They are horizontally split to permit complete accessibility of all internal parts without disturbing the suction and discharge piping.

Here are two-stage pumps that meet the requirements of a wide range of heavy-duty pumping jobs. They have widespread use on boiler-feed service at pressures to 450 psi.

The smaller size pumps feature single-suction impellers which are mounted back to back, with inlets opposed, thereby neutralizing axial thrust. The larger sizes have double-suction impellers which allow the liquid handled to enter simultaneously from both sides. This double-suction design also provides thrust-free operation of

For more data on advertised products, use Readers' Service Cards, last page.



Wilshire Oil Company of California's new catalytic reforming and desulfurizing units at Norwalk, designed and constructed by SWECO to produce high-octane motor fuel.

Teamed to Upgrade Lowgrade

Working together, Wilshire Oil Co. of California and SWECO have been solving process problems since 1923. They've done it again with this new 10,000 BPD Platformer-Unifiner for premium-quality gasoline.

To help satisfy the growing thirst of modern auto engines for higher octane fuels, Wilshire Oil Co. of California decided to add a new catalytic reforming unit at its Norwalk plant. Design and construction were placed in the hands of SWECO's Engineering and Construction Division. A logical choice. The two companies have been working together since 1923, when SWECO built an absorption plant for Wilshire at Santa Fe Springs. And for 34 years, SWECO had been supplying Wilshire with heat exchangers and other process equipment. SWECO was a known *dependable* quantity.

High temperature, high pressure

The Norwalk project was a 10,000 BPD Platformer-Unifiner to upgrade low-octane naphthas. Temperature and pressure requirements were high: The Platformer – using platinum as a catalyst to reform the molecular structure of hydrocarbons–required 975°F., 650 psig. The Unifiner – freeing sulfur from the naphtha to permit high-severity reforming – required 675°F., 850 psig. To meet process requirements, SWECO supplied 13 heat exchangers, designed and manufactured at its Los Angeles plant.

Signed, sealed and "on stream"

Approximately 13 months after SWECO engineers went to work, the Norwalk unit went "on stream." (Total elapsed time included 7 months of field construction.) It's a typical SWECO job. Done right, and done right on time, whether it's in Tanganyika, the Andes, or around the corner in Norwalk, California.

Typical also of SWECO teamwork on all jobs . . . in *engineering and construction* of refineries, chemical plants and ore beneficiating mills . . . in the design and manufacture of *process equipment* . . . in a complete line of *vibrating screen separators* . . . or *extended service* in plant modernization; procurement and expediting; plant operation.

For more information on how SWECO teamwork may help your engineering and construction needs, write for Brochure E-5-333.

SWECO

Southwestern Engineering Company

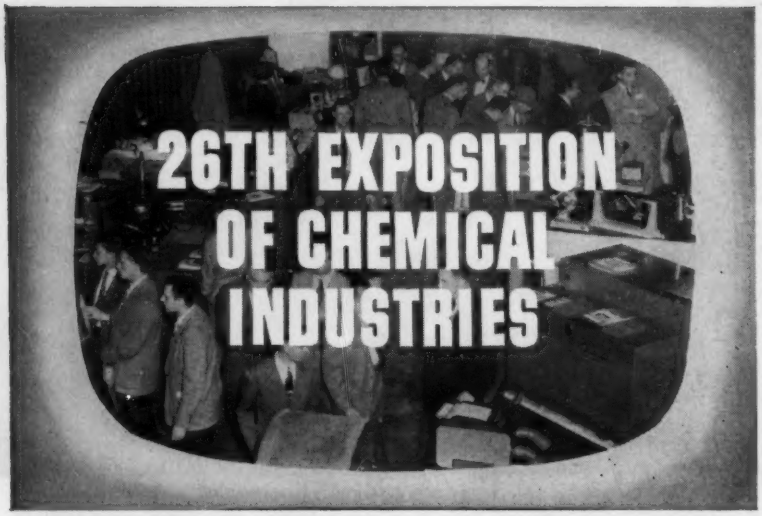
4800 Santa Fe Avenue, Los Angeles 58, California

Engineers and Constructors . . . Manufacturers

Tune in on

What's New

at the



NEW YORK COLISEUM
December 2-6, 1957

Four full floors of fact-filled exhibits—over 500 displays, dramatizing the latest developments in the industry . . . all under one roof . . . new methods . . . new ways to cut costs. They reflect the results of the constant search for new processes, more efficient techniques and improved performance.

Make your plans now to attend with your executives, engineers, designers and chemists. You will find hundreds of new ideas in the latest developments for the chemical industries—processing equipment, materials handling and packaging, laboratory apparatus, chemicals and raw materials, controls and instruments, etc.

For your convenience, new sections have been established for displays of laboratory apparatus and supplies, chemicals and raw materials. This grouping of specific exhibits will save time in securing new and helpful information.

DON'T MISS the greatest concentration of new and important developments ever assembled in one convenient location. You will come away with valuable and profitable new ideas.

Reserve Time and Place Now on Your Calendar.

New York Coliseum, December 2-6, 1957

26TH EXPOSITION OF CHEMICAL INDUSTRIES

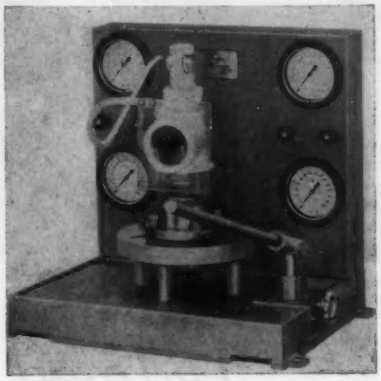
MANAGEMENT INTERNATIONAL EXPOSITION COMPANY

New Equipment . . .

the pump under normal operating conditions.

Ring-oiled ball bearings with water-cooled housings are standard on GT pumps, however self-aligning sleeve bearings can be furnished when specified. The outboard sleeve bearing incorporates a Kingsbury thrust bearing which consists of a collar mounted on the shaft and babbitted stationary thrust shoes. It is pressure lubricated from a viscoil system built into the bearing housing. The inboard sleeve bearing is ring-oil lubricated.

This new bulletin, describes in detail the many advantages of the Class GT pumps. It also incorporates cross-sectional drawings, installation views, selection charts and dimension tables. Ingersol-Rand. **Circle E7 green card, last page**



Portable Tester Requires No External Power Source

A new, bench-type hydraulic and pneumatic test stand called "Porta-Tester" has just been developed for use wherever pressure equipment must be tested without an external source of power. The unit is self-contained, low in cost, portable, and can be operated without previous training.

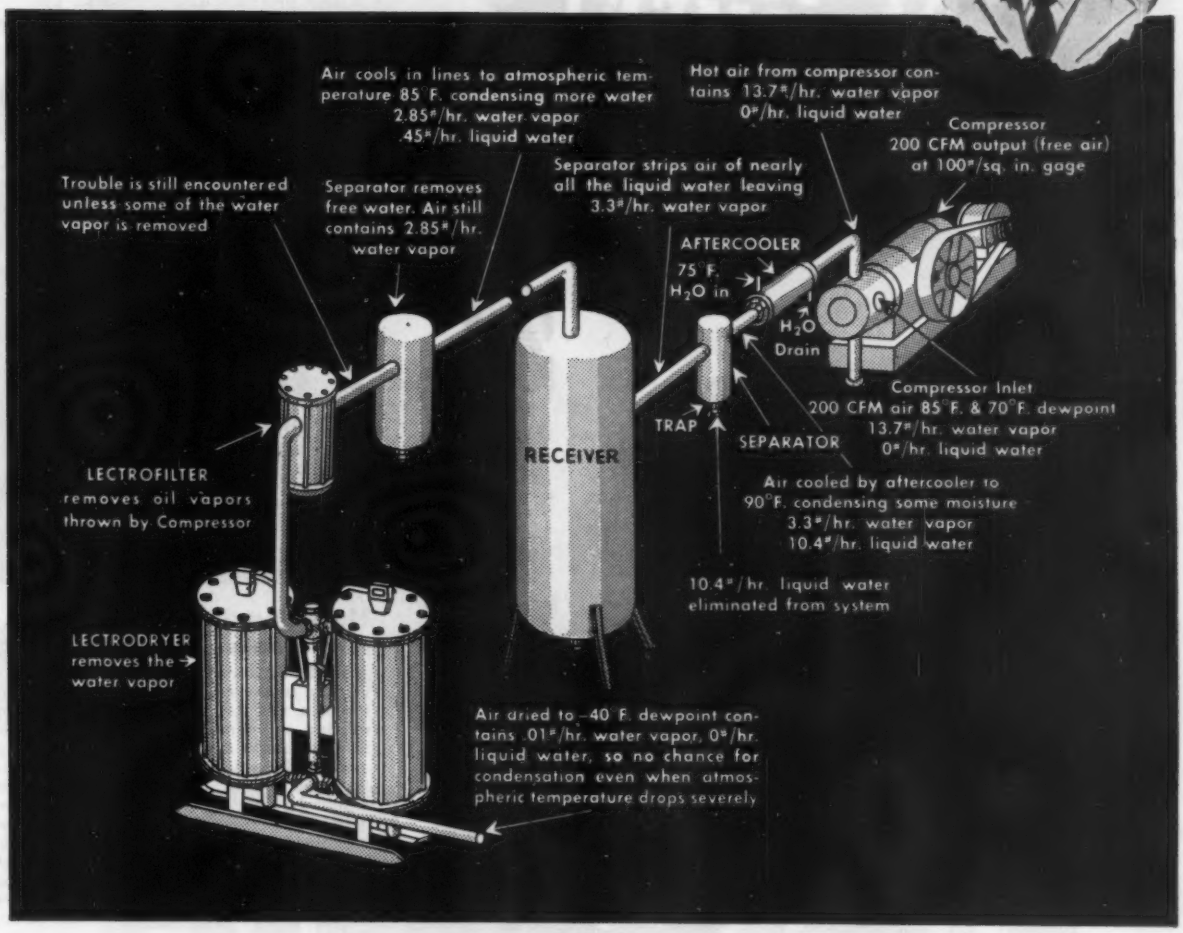
The "Porta-Tester" is designed for testing safety and relief valves, globe, gate, plug and other valves, pressure vessels, piping and pump cases. It is suitable for the liquid testing up to 3000 psi. of male screwed valves ½ inch through 3 inches inclusive and all female screwed valves ½ inch through 1 inch, as well as flanged valves to 4 inches with 600 lb. A.S.A. flanges. The unit is furnished with mounting adapters, hand pump and gages and an air connection is provided for seat-leakage testing. Farris Engineering Corp. **Circle E8 green card, last page**

Teflon Packings Described In New Brochure

Complete service and technical details on chemically-inert mechanical packings fabricated from Teflon are provided in a new brochure on packings. Contents include 15 types of braided construction, C-VU and C-VH rings, six types of molded construction, cup and cone rings and combination sets.

The company's packings are manufactured in a variety of types, styles and sizes to meet every industrial service condition. They can be used to handle any

An instrument man tells why he uses a LECTRODRYER* on every control system


Air cools in lines to atmospheric temperature 85 F. condensing more water
2.85#/hr. water vapor
.45#/hr. liquid water
Hot air from compressor contains 13.7#/hr. water vapor
0#/hr. liquid water
Compressor
200 CFM output (free air) at 100#/sq. in. gage
Trouble is still encountered unless some of the water vapor is removed
Separator removes free water. Air still contains 2.85#/hr. water vapor
Separator strips air of nearly all the liquid water leaving 3.3#/hr. water vapor
AFTERCOOLER
75 F. H_2O in
H_2O Drain
Compressor Inlet
200 CFM air 85 F. & 70 F. dewpoint
13.7#/hr. water vapor
0#/hr. liquid water
TRAP
SEPARATOR
RECEIVER
LECTROFILTER removes oil vapors thrown by Compressor
Air cooled by aftercooler to 90°F. condensing some moisture
3.3#/hr. water vapor
10.4#/hr. liquid water
10.4#/hr. liquid water eliminated from system
LECTRODRYER removes the water vapor
Air dried to −40 F. dewpoint contains .01#/hr. water vapor, 0#/hr. liquid water, so no chance for condensation even when atmospheric temperature drops severely

Aftercoolers, traps and separators catch only the free water in compressed air. Vaporous moisture gets out into the lines and condenses—a trouble-maker at instruments, valves and air motors.

Rust, mud and ice form and interfere with sensitive controls. But not on a system safeguarded by Lectrodryer equipment. The above chart tells you why.

Whether your controls call for large or small amounts of air, there are Lectrodryers in sizes to suit. Bulletin 223B describes them. For a copy, write Pittsburgh Lectrodryer Division, McGraw-Edison Company, 307 32nd Street, Pittsburgh 30, Pennsylvania.

Lectrodryer

*REGISTERED TRADEMARK U. S. PAT. OFF.

For more data on advertised products, use Readers' Service Cards, last page.

DOYLE & ROTH
"DEPENDABLE"
HEAT TRANSFER
EQUIPMENT

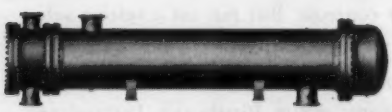
FOR GREATER ECONOMY
and
DIVERSIFIED APPLICATION

In the *modern and up-to-date* Doyle & Roth plants, we have *every means* of designing, developing and fabricating precision tubular products.

Our engineering department has met many *unusual problems* requiring extensive knowledge in the field of heat transfer engineering. *This "know-how" is available to you.*

D. & R. also passes on to you, the economies of its *standardization program.* Starting with engineering and following through on construction, *economies are substantial.*

Materials are purchased to *rigid specifications* and *standard components are stocked.*



✻ CONTACT DOYLE & ROTH
For prompt attention to your
INDIVIDUAL REQUIREMENTS

DOYLE & ROTH
Manufacturing CO. INC
136-50 TWENTY-FOURTH STREET, BROOKLYN 32, N. Y.

New Equipment . . .

industrial acid, solvent, corrosive or alkali. Operating temperatures range from —120 to 500 F.

The new brochure gives specific recommendations as to services, applications and temperatures. Information on pressures, dimensions and mechanical requirements is also provided. Crane Packing Co.

Circle E9 green card last page

New Electrical Tape Fuses Into a Solid After Wrapping

Made of an entirely new formula developed in the company's research laboratories, a new tape, has been designed for splicing and terminating either plastic or rubber cables. For connections operating under 2000 volts it serves as both insulation and sheath . . . no other tape is required. This "two-tapes-in-one" feature is possible because Okoweld, while possessing optimum electrical characteristics, is also resistant to weather, chemicals, flames and mechanical abuse. It can jacket as well as insulate. Another feature—it comes in five colors for phase and circuit color-coding.

Upon application, this new tape rapidly fuses into a solid, homogeneous wall around the connection. No adhesives are involved. Okoweld is listed by the Underwriters' Laboratories, and is the only self-fusing tape approved by them for use as ". . . sole insulation and covering of joints and splices in electrical conductors." The Okonite Co.

Circle E10 green card, last page

Welders Goggles Have Prescription Lenses

The availability of the first flash goggles with prescription lenses is announced.

The goggles, new in the welding industry, are for wear under the welding helmet or hand shield in inert-gas-shielded metal-arc welding, as recommended in the safety standards of the American Welding Society.

Heretofore, many welders who wear glasses have had insufficient eye protection because there are no goggles avail-

Acids and acid industrial atmospheres will ruin some insulations . . .

FOAMGLAS®

INSULATION

is acid-proof!

—like any true glass, FOAMGLAS is not attacked by common acids and acid fumes. And inorganic FOAMGLAS is the only thermal insulation which combines all these additional performance benefits in one material: it is waterproof and vapor-proof . . . incombustible . . . has remarkable compressive strength . . . is easy, economical to handle and install. Write today for detailed literature.

Pittsburgh Corning Corporation

Dept. Z-107, One Gateway Center, Pittsburgh 22, Pa.

In Canada: 57 Bloor Street West, Toronto, Ontario

BY-PRODUCTS...

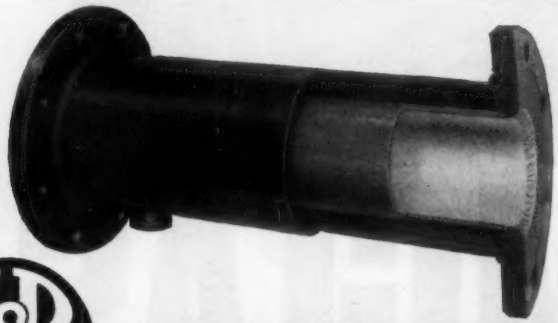
will PURCHASE or REFINE . . . for your account.

The facilities and experience of Truland may be employed advantageously for the economical upgrading and disposal of solvent mixtures and organic by-products. Our technically trained personnel are available to discuss the refining of any solvent mixture or organic by-products.

Send for new booklet which describes our operation

TRULAND
CHEMICAL CO., INC.
EAST RUTHERFORD
NEW JERSEY

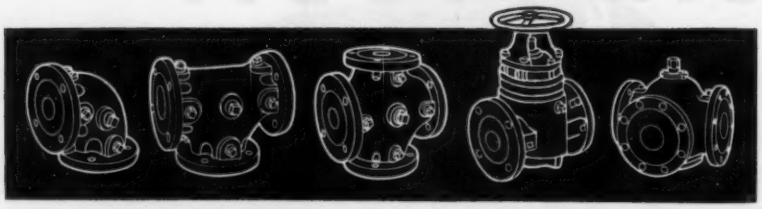
Division of The Trubek Laboratories Incorporated



H&B **JACKETED PIPE and FITTINGS**

● The above cutaway illustrates H & B standard jacketed welded pipe and fitting construction, designed to allow complete jacketing of the product pipe. Special jigs and fixtures enable H & B to insure complete uniformity of the jacket area in relation to the O D of the product line and the I D of the jacket pipe. All H & B jacketed equipment is hydrostatically tested at 450 to 500 p.s.i. H & B welded steel jacketed fittings are ideally suited for process piping of pressures reaching 300 p.s.i. and temperatures up to 750°F.... A few of these fittings and valves are illustrated below. For more information send for bulletin J-57.

HETHERINGTON & BERNER INC. • 747 KENTUCKY AVE., INDIANAPOLIS 7, IND.



New Equipment . . .

able which will fit over their glasses and under a welding helmet. The new prescription flash goggles offer a practical solution of this problem.

They are obtainable in ten lens styles; variations of the single-vision, bifocal, and trifocal types. As specified in the safety standards, they have side shields, and the lens shade is number two. Air Reduction Company.

Circle E11 green acrd, last page

94-Page Wire Rope Catalog Has Metallurgical Tables

This company has announced publication of a new catalog illustrating its line of industrial wire cloth, screens and wire cloth products.

Within its 94 pages, the new volume includes a complete description of the types and sizes of industrial wire cloth available, typical applications and a number of useful metallurgical tables. A completely new section also gives standard trade definitions and ordering information. The Cambridge Wire Cloth Co.

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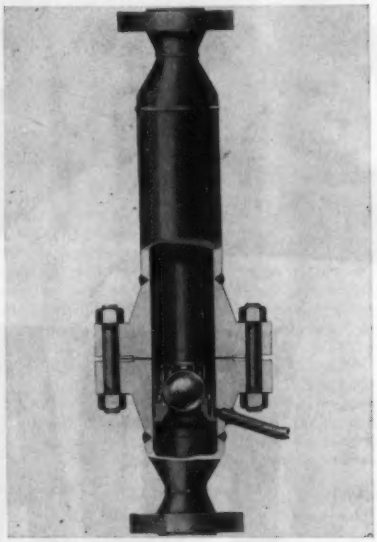


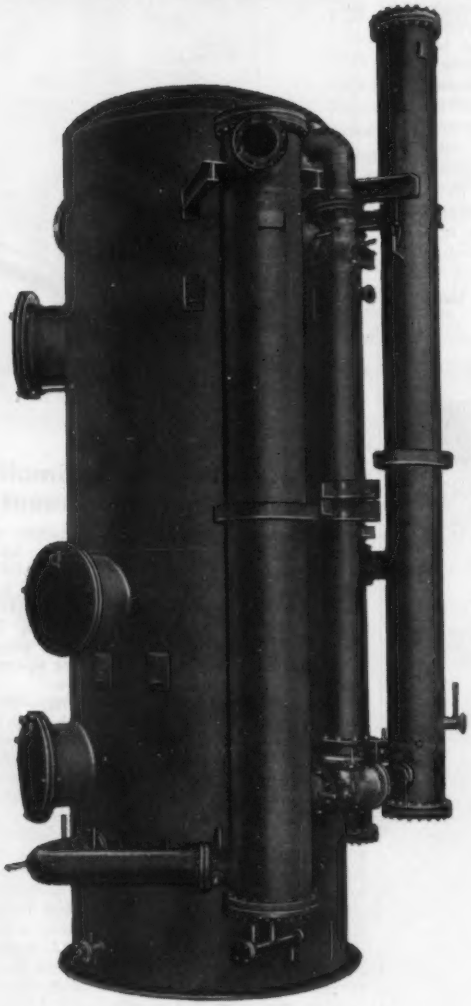
New Design Desuperheater Uses No Spray Nozzles

A new desuperheater, just developed, represents an advanced approach to desuperheater design. Tests over such a wide load range as 50 to 1 show that reduced steam temperature can be held constant to meet the most rigid quality demands only 20 feet downstream from the desuperheater outlet.

No long run of piping is needed to mix cooling water intimately with steam. There are no spray nozzles, traps, glands or stuffing boxes to require maintenance. Furthermore, no atomizing steam is needed.

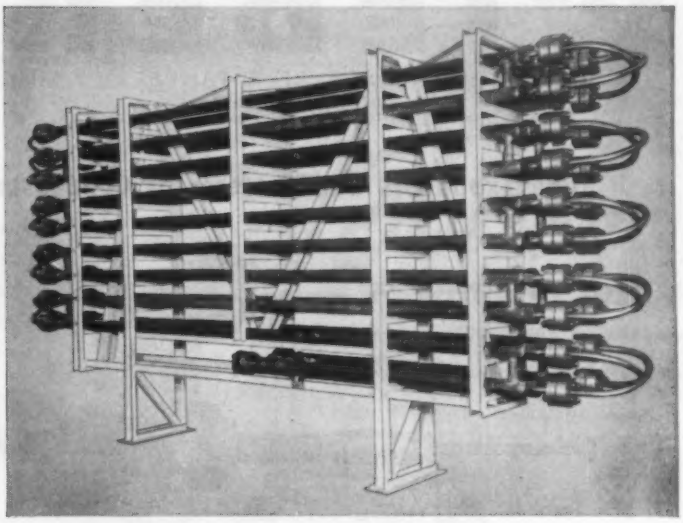
The desuperheater consists of a section of steel pipe enclosing a self-regulating orifice extending around 360 degrees and a weighted ball held in concentric position by Inconel springs. Cooling water, under the control of a diaphragm-operated valve

HEAT EXCHANGERS to match your special needs



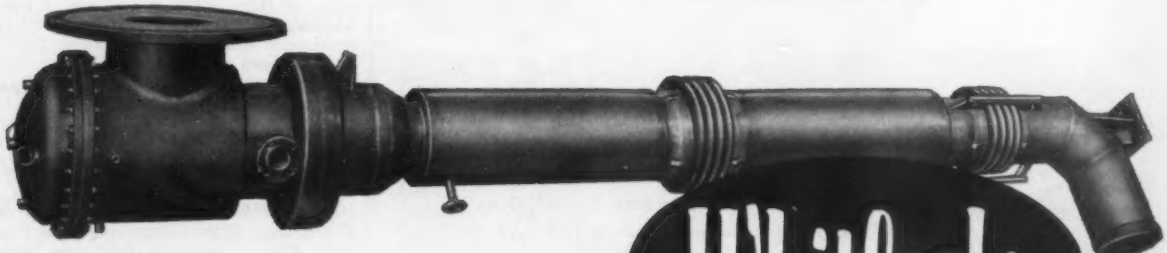
You can depend on Whitlock Heat Transfer Equipment to satisfy your most complex requirements. Whitlock designs and manufactures not only the standard sizes and types of heat exchangers, but special exchangers for high and low temperature service, for operating pressures ranging from complete vacuum to thousands of pounds per square inch, constructed of almost any workable material. These exchangers are supplied as individual units, semi-packaged systems, or packages having complete operating controls. Write for recommendations and Bulletin 250.

THE WHITLOCK MANUFACTURING CO.
75 South St., West Hartford 10, Conn.
In Canada: Darling Brothers, Ltd., Montreal



Typical of many packaged units regularly manufactured by Whitlock, this large convertor with auxiliary heat exchangers comprises a complete operating unit. Whitlock Engineers are thoroughly experienced in designing heat transfer equipment to meet your special operating conditions.

A primary aftercooler designed to remove the heat generated in compressing ethylene gas to 3700 lbs. per square inch. The inner cooler tubes containing this pressure are of heavy wall seamless steel, with their external walls protected by a cladding of admiralty metal from corrosion by the water in the outer pipes.



Secondary gas precooler is one of nine used with the reactor in a modern chromium ore plant. This stainless steel cooler reduces stack gas temperature from 1500° employing cooling water at about 100°F. Since it was necessary to provide means for accommodating the expansion of component parts due to the elevated temperatures, two corrugated expansion joints were included in designing the unit.

Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

responsive to a temperature controller, enters the orifice chamber at a uniform rate of flow around the 360-degree periphery.

In operation, the force of the steam flowing through the desuperheater raises the ball an amount determined by weight of the ball and amount of steam flow. Each rate of steam flow gives the ball a different position, with a practically-constant pressure drop—normally 3 to 4 psig —for all flows.

Cooling water enters the steam at the seat of the orifice, the point of highest pressure drop. With the ball held in concentric position by the springs, the incoming steam flows uniformly around the 360-degree periphery through which the cooling water is introduced. Introduction of cooling water is further aided by the aspirating effect created by pressure drop in the steam passing through the annular restriction between the ball and ring.

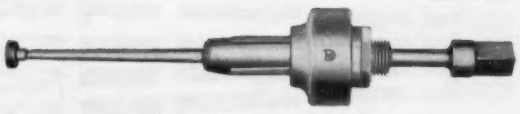
The result is high turbulence regardless of rate of flow, with instant and intimate mixing of cooling water into the steam for complete vaporization. Since the desuperheater body is always mounted vertically, water not immediately absorbed remains in suspension until completely dissipated. Copes-Vulcan division, Blaw-Knox Co.

Circle E13 green card, last page

WIEDEKE

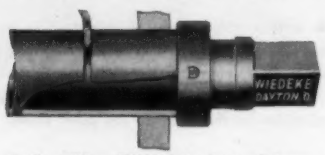
THE QUALITY NAME IN TUBE EXPANDERS . . . SINCE 1892

Tube Expanders and Cutters for Condensers



No. 255—for average tube sheets

No. 270—for thick or multiple tube sheets



Series 400—IDEAL Tube Cutter (shown in use) for non-Ferrous Tubes. Available in sizes for ⅝" and larger Tubes.

#37

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Confidence is your assurance that IDEAL products will get your job done—and done *right*. The Gustav Wiedeke Company has specialized in Tube Expanders, Tube Cutters, and Operating Accessories since 1892. Write for *new* General Catalog 81.

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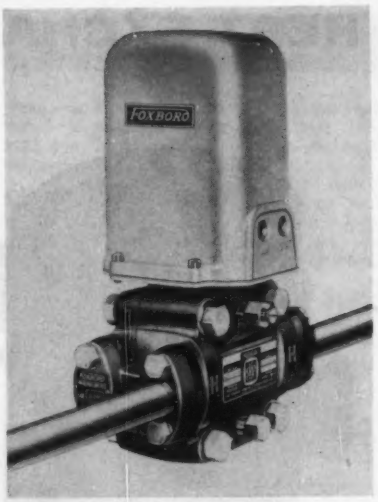
Dayton 1, Ohio



Measure and Transmit Small Flows With New Instrument

Small flows, with a minimum range of 0.003 to 0.010 gpm of clean water and similar liquids and from 0.010 to 0.040 scfm of air and other gases, can be measured and transmitted by a new Integral Orifice d/p Cell Transmitter. It was developed to meet research and pilot plant needs, as well as for process operations such as rationing small flows.

The new instrument has a manifold with a removable orifice through which the measured fluid flows. Resulting pressures across the orifice are applied to the high and low pressure sides of a standard silicone-filled twin diaphragm capsule. The resulting differential, balanced by a pneumatic feedback mechanism, produces a 3-15 psi output signal proportional to differential pressure for remote indication or recording.

Six standard orifices in bore sizes from 0.020 to 0.250 inches are available with the transmitter. Simple removal of manifold permits change of orifice for new flow range. A conversion kit containing set of orifices and manifold is also available so that existing transmitters of the 13A type can be converted in the field to measurements of small flows.

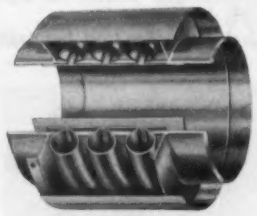
Since transmitter is installed directly in a process line, it needs no separate primary device and therefore no meter leads. Transmitter range is adjustable between the limits of 0-20 and 0-250 inches of water. Maximum working pressure is 1500 psi; maximum working temperature, 250 F. The Foxboro Co.

Circle E14 green card, last page

Data Book Describes All Types of Strainers

A new complete bulletin on start-up, or temporary strainers has just been completed. This is an engineering data handbook showing all sizes from two inches through 24 inches in the regular flange series and the ring joint type. All types, including cone, basket and flat are illustrated, with various sizes, giving 100 percent and 200 percent pipe opening. Perforated steel, along with woven wire types are illustrated. Where large types require fine mesh, special structural metal to support the fine wire mesh has been designed and illustrated. These strainers come in all normal steel, stainless steel

NEW ZALLEA HyPTor* TOROIDAL EXPANSION JOINT



HyPTor corrugations have a circular or toroidal cross section which provides a lower operating stress at any given pressure than any other corrugation shape.

For unequalled endurance at pressure and temperature extremes

This unique toroidal expansion joint with thin-walled bellows is setting new performance and durability records in high pressure, high temperature service. It was developed to meet the severest operating conditions without sacrificing long life.

Minimum stress at high pressures is one advantage of the Zallea HyPTor. This is due to the thin-walled bellows and toroidal corrugations. Thin walls develop lowest flexing stress. The toroidal cross section assures lower operating stress at any pressure.

Superior performance at high temperatures. The toroidal corrugation of the HyPTor makes it suitable for use at high temperatures. Also, the HyPTor is hydraulically formed and free from circumferential welds which would act as stress raisers.

Longer life on the job. The ability of the HyPTor to absorb punishment without ill effects has been proved in service. A number of HyPTor Expansion Joints designed for 700 psi working pressure, were installed in liquid oxygen service in 1948. They are still operating . . . at pressures up to 2300 psi.

Get the complete story of the new Zallea HyPTor Expansion Joints. Our new 72-page Expansion Joint Manual gives full details—plus worthwhile information on basic types, design and installation data, expansion joint selection and recommended specifications. Write on your Company letterhead, for your free copy of Catalog 56, Zallea Brothers, 890 Locust Street, Wilmington 99, Delaware.

*Patented

Zallea
expansion joints

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World's largest manufacturer of expansion joints.

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CONCO GUN AND CLEANING PLUGS

The Conco Gun and Cleaning Plugs economically keep steam condenser and heat exchanger tubes clean. They are typical of the many Conseco Specialty Items that guarantee economical, efficient Power Plant and Engine Room operation.

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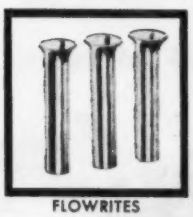
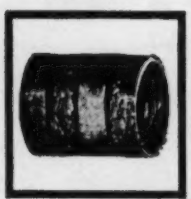


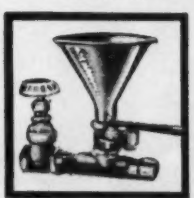
FLOWRITES

BEVEL GEARS

FIBRE PLUGS



FIBRE AND METALLIC PACKING



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Descriptive Bulletins Sent Promptly 18

New Equipment . . .

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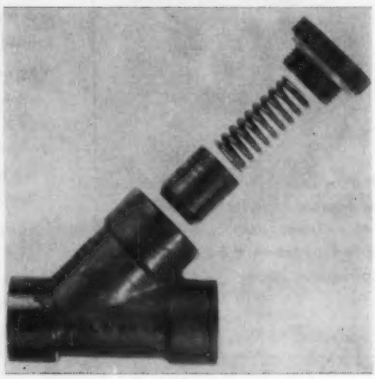

All-Plastic Check Valve Operates 2 Million Cycles

The first all-plastic lift check valve has just been introduced. Body and components of the new valve are made of normal impact rigid polyvinyl chloride to provide high corrosion resistance to alkalis, acids, inorganic salt solutions and other corrosive flow material. A highly durable PVC spring positions the disc to assure quick and complete shutoff.

The new PVC check valve operates successfully at pressures up to 150 psi at 75 F. Complete shutoff was obtained with the valve during and after 2 million continuous cycles under 125 pounds of air and 50 pounds of water.

A long service life for the valve is provided by the all-PVC construction. The valve has been completely immersed in corrosive fluids for a long period of time without any damage to its body and components. The PVC spring which controls the valve's discs retained its resilience after several million operating cycles. Walworth Co.

Circle E16 green card, last page

68-Page Book Describes Anhydrous Ammonia Uses

A new, 68-page technical data book on anhydrous ammonia and ammonia liquor has just been prepared.

The book fully describes anhydrous ammonia and ammonia liquor, listing their chemical and physical properties, specifications, handling and storage features, unloading methods, analytical procedures, and bibliography.

Graphic illustrations include data pertaining to viscosities, density, vapor pressures, boiling and freezing points, and other characteristics. Allied Chemical & Dye Corp.

Circle E17 green card, last page

Lube Manual on Plug Valves Prescribes Lube Selection

A new 12-page illustrated plug valve lubricating manual has been issued. The new manual describes the function of lubricants in lubricated plug valves and the essential properties of an effective lubri-

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In a few days time you can have a plan in your hands that took over forty years to develop.

You benefit, that is, from Plibrico's more than forty years of dealing with refractory and combustion problems. All that experience is directly applied to your job by our Engineering Department. From this department came such developments as Plibrico's M-1 Specification, eliminating costly supporting armor while allowing our two-component lining to do the job at low initial cost, with service equaling or excelling other methods. Such are the makings of a "pro".

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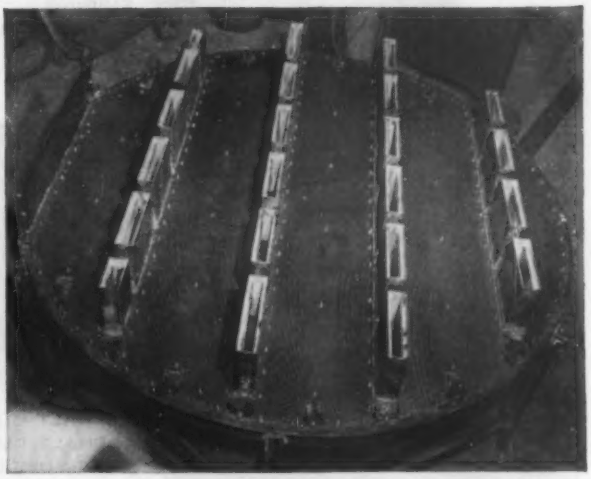

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Now you can equip fractioning towers with internals fabricated of Hendrick perforated metal plate. Hendrick "custom-tailors" perforated metal decks in commercially rolled metals and gauges to meet your own detailed specifications. Modern Column Internals produce greater capacity . . . reduce high cleaning and replacement costs caused by fouling and corrosion. And they're fabricated of Hendrick's own perforated metal . . . clean cut perforations assure uniformity of mesh and long service life. For more detailed information mail the coupon below and let us set up a date to meet with your process designer.

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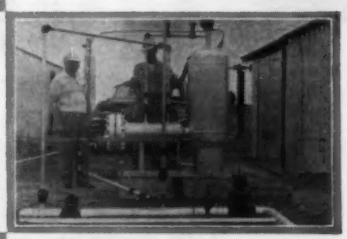

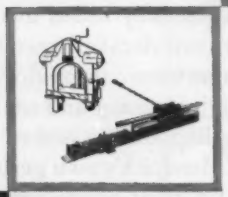

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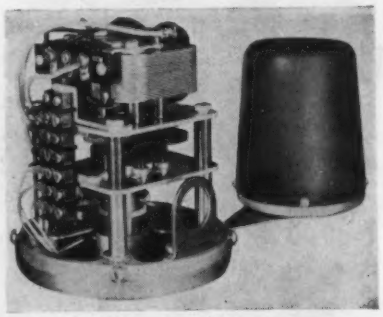
New Equipment . . .

cant. Detailed information on how to select the right lubricant and how to apply it is presented in text and pictures.

A two-page chart lists more than 560 flow materials which lubricated plug valves service, and opposite each is its recommended lubricant number. The service range of each lubricant is presented in another chart along with a description of the lubricant and its temperature range. Walworth Co.

Circle E18 green card, last page



Shaft Mounted Gearmotor Provides Remote Control

A new shaft mounted gearmotor provides remote electrical control with indication of position, speed, valve setting, etc., obtained on a calibrated meter.

The Shaftrol includes a built-in potentiometer that provides remote indication and control for valves, variable speed drives, gates, jacks, and variable displacement pumps. The potentiometer may also serve in bridge circuits of automatic control systems. Control may be by dial control, by push button (as indicated in the photograph) or it may be automatic from limit switches, controllers or proportioning devices.

The Shaftrol mounts on shafts from one-fourth-inch to one-inch in diameter. Installation is quickly made through use of a mounting shaft collar. Shaftrols are furnished with a torque arm that compensates for any runout that may be present in the shaft on which the gearmotor mounts. A wide range of operating speeds and torques can be had by specifying the desired ratio of the three or four stage reduction gearing. A variety of potentiometer gear ratios may also be had so that full scale deflection of the calibrated meter may be obtained for rotation of the driven shaft from one-sixth revolution to 40 or more revolutions. Limit switches, which are optional, may be set to limit travel to any desired amount. The Jordan Co., Inc.

Circle E19 green card, last page

Booklet Compares Costs of Heat Exchanger Design

Announcing the publication of a new booklet on "Design and Cost Comparison of Heat Exchangers . . . Using Wolverine Trufin."

This new booklet should be of assistance to engineers, estimators and designers. It will give a rapid analysis of the comparable costs between a plain condenser tube and a Trufin Type S/T shell

5 STEPS

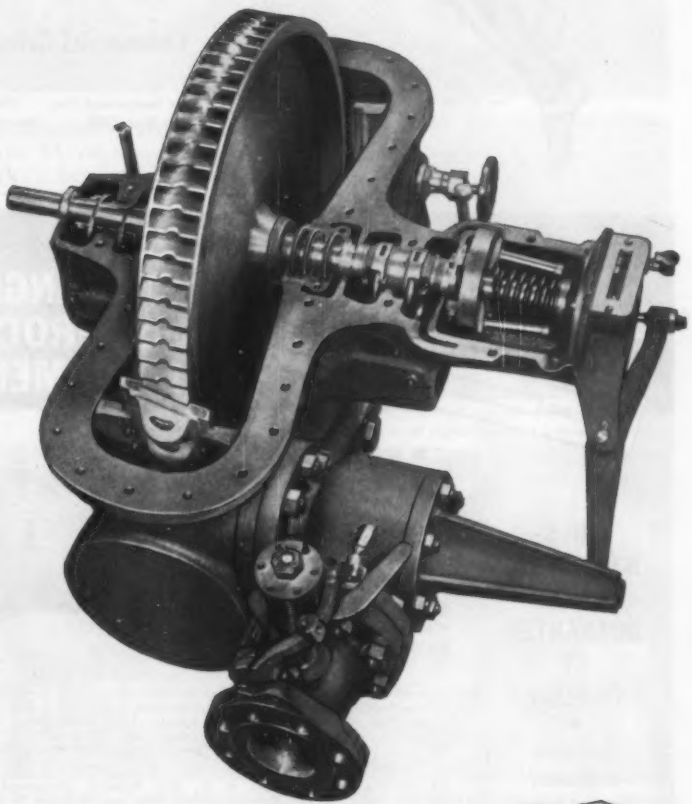
in making an almost indestructible turbine

The rotor of a Terry solid-wheel turbine is a single forging of special composition steel. It is first rough turned in two operations, as shown, and then two cuts are taken to mill the semi-circular buckets from the solid metal. The wheel at the top has been finished, ready for mounting on the shaft. *The result is a single-piece wheel with no parts to loosen or wear out.*

Blade wear, which might occur after many years of usage, is not important, because the power-producing action of the steam takes place on the curved surfaces at the backs of the buckets. Thus wear does not materially affect horsepower or efficiency.

The blades can't foul. They have a one-inch clearance, and are further protected by the projecting rims at the sides of the wheel.

The Terry solid-wheel turbine is an extremely reliable piece of equipment. Write for details—today. Ask for a copy of bulletin S-116.



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And the best *complete* anti-rust protection for iron and steel is hot-dip galvanizing. The hot-dip process seals out corrosion on *all* surfaces, as no other protective coating can. Armor-plate your iron and steel with hot-dip galvanizing by the Southwest's largest commercial galvanizers, the Nowery J. Smith Company!

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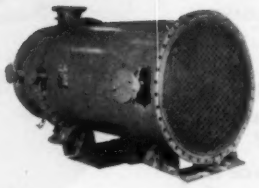
CODE CONSTRUCTION: A.S.M.E. Code Stamped and to T.E.M.A. Specifications
MATERIALS: All Carbon Steel
PHYSICAL DIMENSIONS: Shell—44" dia., 8'9" Length, 1 1/16" thick, 1500 Steel Tubes (¾" O.D. x 14 B.W.G.)
TEST PRESSURE: 415 lbs.
DESIGN TEMPERATURE: 450°F
WEIGHT: 9500 lbs.



As a result of our many years of experience we at M&L have an unusually thorough knowledge of the appropriateness, adaptability and qualities of fabrication of a wide variety of metals. This accumulated knowledge, coupled with our engineering experience and the important "extras" in fabrication is your assurance of practical trouble-free equipment . . . at the lowest possible cost.

An excellent case in point, is the Still Reboiler illustrated above. In the fabrication of the Reboiler, every seam was X-rayed to make absolutely certain the welding job was perfect. This is typical of the "extra" care you can expect and get from M&L.

Why not call on us the next time you need equipment. We design and construct to A.S.M.E. and A.P.I. code or can build to non-code standards. Please state all conditions of service.

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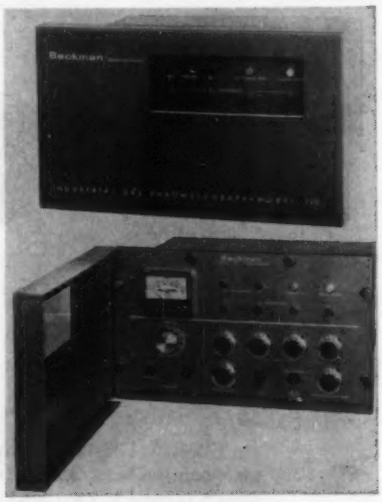
New Equipment . . .

and tube exchanger over the range of the more common applications.

Companies using shell and tube exchangers will be able to quickly estimate not only where Trufin Type S/T should be used but the economies of specifying Trufin in specific applications. Wolverine Tube. **Circle E-20 green card last page**



New Unit Analyzes 4 Gas Components Continuously

The availability of a new, low cost industrial gas chromatograph control unit and analyzer section for the continuous analysis of as many as four components of a specific gas stream, was recently announced.

The chromatograph features two distinct instruments which can be placed as much as 1500 feet apart yet maintain accurate measuring and recording. The chromatograph features simplified control, visual and permanent recorder readout, an accuracy of + or — one percent, a locking door, an integrated test circuit to facilitate periodic maintenance without disassembly, and automatic or manual operation.

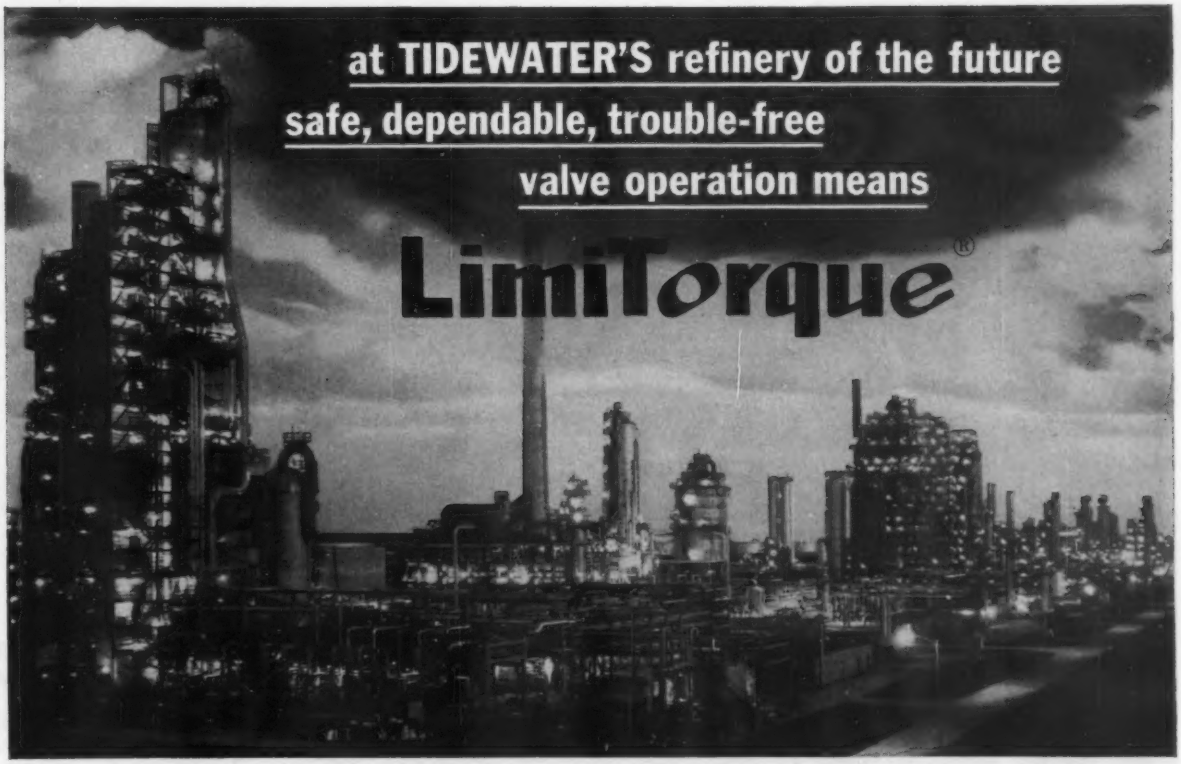
It features + or — 0.2 degrees C temperature control for operation up to 110 C and provision for true split column operation allowing complete analysis of up to four high and/or low boiling point components in a single stream. A single action five-way linear sample injection valve which duplicates the action of five conventional two-way valves is the heart of the gas handling system. Beckman Instruments, Inc.

Circle E21 green card, last page

Nuclear Systems For Producing Electricity

The company has just announced the publication of a paper reviewing reactor systems to produce commercially useful electricity from nuclear energy.

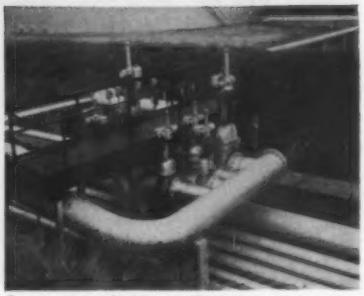
The paper, which presents a detailed picture and word description of various systems using water, gas, sodium and liquid-fuel as coolants, originally was presented as a lecture this year, at the



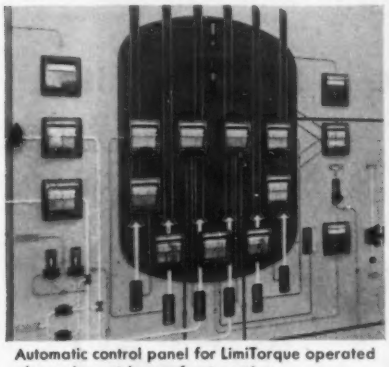
Here, at the World's newest and finest refinery where equipment standards are high . . . technology far advanced . . . six LimiTorque type S3 valve operators at the base of the big "cat" recycle catalysts around the clock . . . help maintain throughput capacity of 102,000 BPD.

In fact, in the refinery section alone 134 LimiTorque Motorized Controls provide safe, automatic, trouble-free valve operation. LimiTorque is more than proud to have played a part in this tribute to American ingenuity.

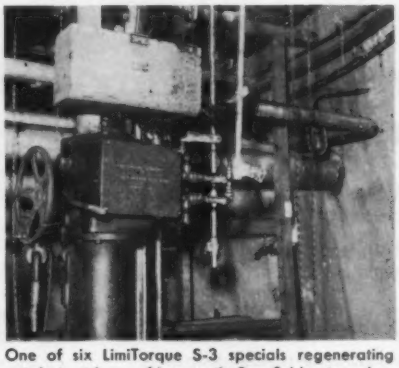
Wherever automatic, remote valve operation is required, LimiTorque will provide rapid, precise control under a wide range of operating conditions. Actuated by electricity, hydraulic pressure, air, or high pressure gas, LimiTorque can be readily field mounted on existing valves. For specific applications, contact your valve manufacturer or nearest LimiTorque representative.



One section of eight LimiTorque operators controlling flow of crude oil to and from tank farm.



Automatic control panel for LimiTorque operated plug valves at base of cat cracker.



One of six LimiTorque S-3 specials regenerating catalysts at base of huge orthoflow fluid cat cracker.

LimiTorque motorized valve controls operate 36 in. valves on ten giant twin strainers.

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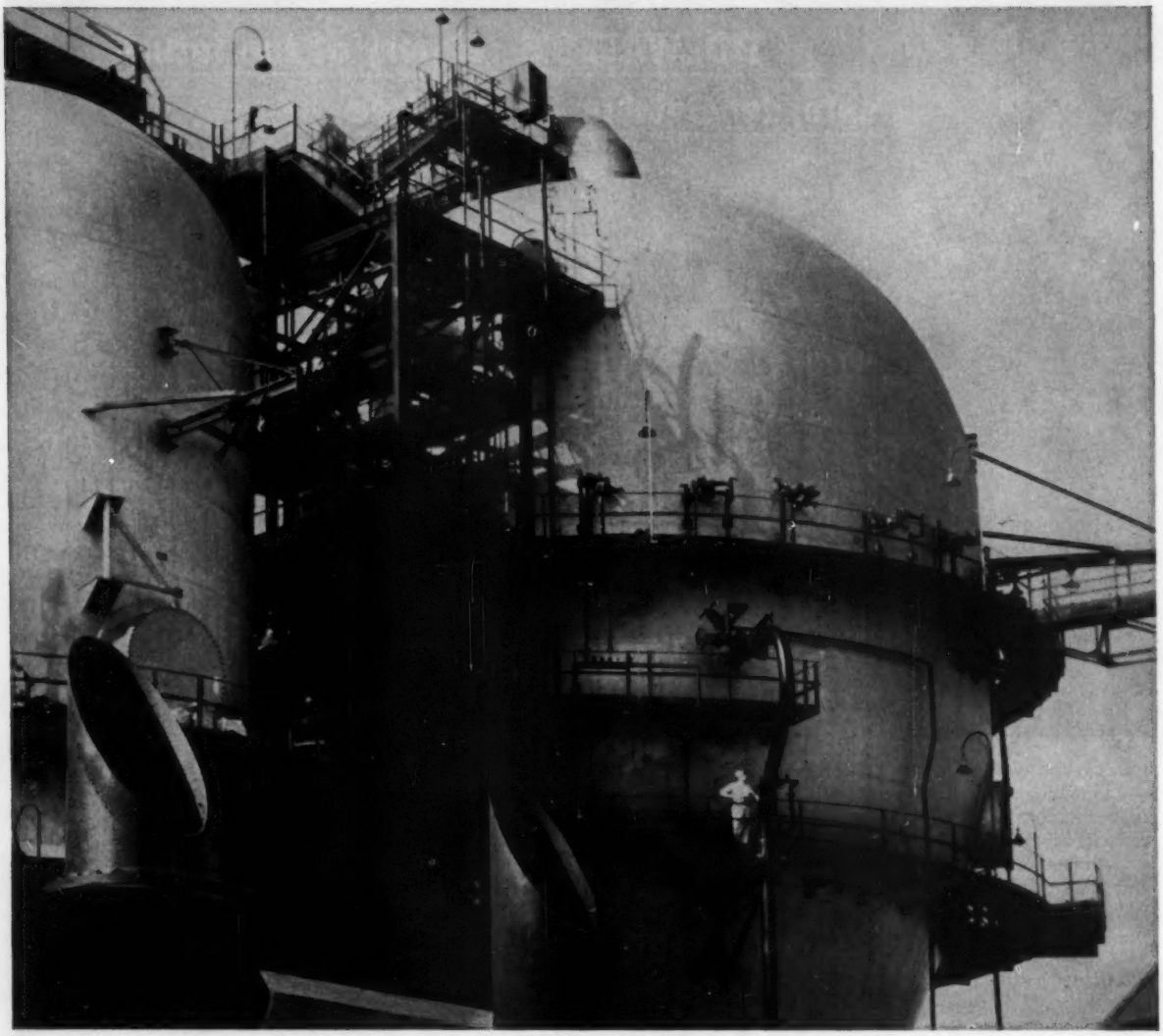

ONE OF THE WORLD'S LARGEST CAT CRACKERS benefits from concrete linings made with Atlas Lumnite cement. Constructed at Gulf Oil's Philadelphia refinery by The M. W. Kellogg Company, it has 64,000 bbl. daily capacity, producing high-octane motor fuels, heating oils, propane-propylene, butane-butylene. Reactor tower (30' 8" x 71') and regenerator (56' x 84') are lined with an insulating castable made with Lumnite cement.

For long service, economy—line refinery units with concretes made with Atlas LUMNITE*

- Industrial concretes made with Lumnite cement and suitable aggregates resist heat, combat corrosion and provide insulation.
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- Service life of installations is extended.

For maximum convenience, use Lumnite-made castables. These are packaged mixtures, ready for use. Just add water, mix and place. Made and distributed by leading manufacturers of refractories. For more information, write: Universal Atlas, 100 Park Avenue, New York 17, New York.

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*"LUMNITE" is the registered trademark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

-156

UNIVERSAL ATLAS CEMENT COMPANY – member of the industrial family that serves the nation – **UNITED STATES STEEL**

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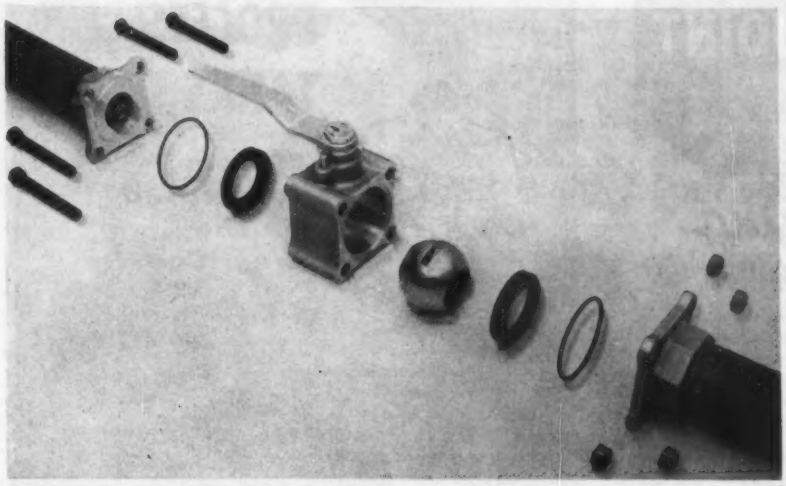
New Equipment . . .

European Atomic Energy Courses for Management in Paris, France. General Electric Co. **Circle E22 green card, last page**



Ball Valve Combines Union With Valve in One Unit

A new concept, combining the functions of a union and a ball valve in one compact unit, has just been introduced.

With the use of this valve, the necessity of installation of a separte union to provide a breaking point in the line is eliminated. In-line maintenance is also possible by the simple expedient of removing four bolts, lifting the center section (which contains all renewable parts) from the line and make necessary replacements. With the opening in the ball and seat rings maintaining the same smooth shape as the inside of the pipe, resistance to flow is well below that of globe or gate valve and

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1. **Backlighted nameplates or bullseye indication.**
2. **Sequential alarm identification.**
3. **Easy adaption for use with Scam DU-ALL annunciators for HI-LO indication.**
4. **Optional ringback or manual reset functions by the operation of a slide switch.**

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• This rental rate is well below the prevailing rate for this choice location. This space will provide maximum flexibility for any type of business operation.

* Space formerly occupied by TIME, Inc., Publishers of TIME, LIFE and FORTUNE magazines.

For detailed information contact Van Holt Garrett Jr.

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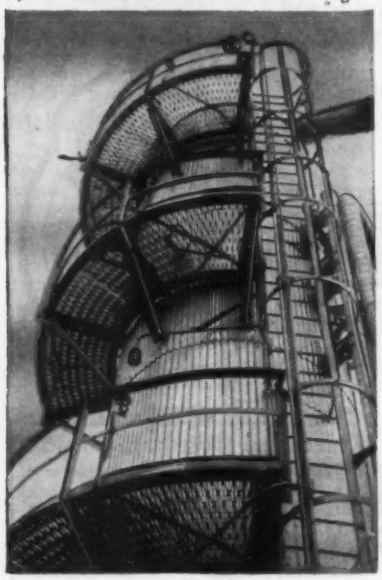
You too should be using KROIL every day. Try it on money-back basis. Gallon $4.00; with Kroiler trigger squirt gun (shoots a drop or a stream 15 feet, if desired) $4.95, f. o. b. our factory.

KANO LABORATORIES 1094 Thompson Lane, Nashville 11, Tenn.

KANO LABORATORIES

RAIN OR SNOW CAN MAKE CATWALKS DANGEROUS



Walkways, catwalks and treads made of solid wood, metal or other material can collect snow, rainfall, grease or oil and become dangerously slippery.

But these walking surfaces, made of an open mesh of metal bars on edge, cannot collect these substances, leaving the surface always clean, dry and tractional for safer access to high places.

As founders of the grating industry, the Irving Company can draw upon over half a century of experience to supply you with quality grating products for catwalks, treads and other practical and economical uses.

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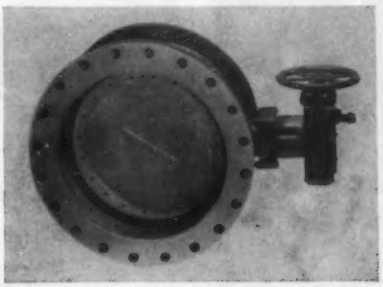
friction is reduced to a minimum. Operation of the valve is unaffected by reversal of flow, as the ball is fitted with twin seals, one on either side.

In order to accommodate a wide range of media, seat and seal materials may be of Buna-N, Hypalon, Neoprene, Natural Rubber or Teflon. Components made of these latter materials are easily interchangeable by the method described above should the media in the system be changed following installation. Worcester Valve Co., Inc. **Circle E23 green card last page**



Butterfly Valve With Rubber Seat Provides Tight Shutoff

The production and availability of a new line of butterfly valves, featuring a rubber seating principle and unusual operating characteristics, is now announced.

Advantages claimed for this new type of butterfly valve include: lower operating torque, adjustability of seat for tight shutoff, seat replacement without removal of shaft or operator, elimination of shaft sealing problems as the rubber seat is a continuous ring integral with the disc, and, increased operating cycles before part replacement or maintenance is necessary. Darling Valve & Manufacturing Co.

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Change Single to Three Phase With New Converter

Weighing only 39 pounds, this compact, light-weight converter changes single phase, 115 volt, 60 cycle AC to three

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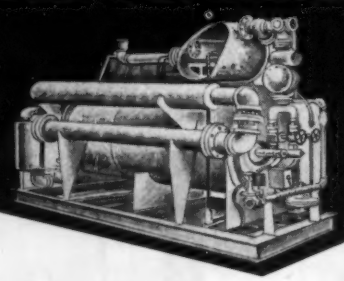

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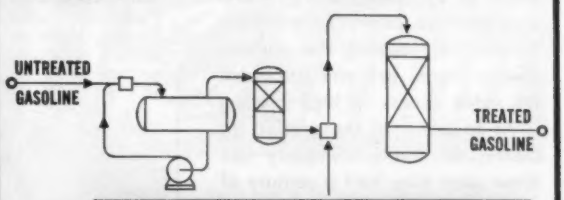

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phase, 230 volt, 60 cycle current. Frequency is held constant within a fraction of a cycle. The durable aluminum alloy frame houses capacitator starter as well as both output and input receptacles, and is about 10 inches high without carrying handle. Intake and exhaust air vents are located in lower halves of endbells, making the converter drip proof. Heavy duty grease sealed ball bearings produce very little noise. Kato Engineering Co.

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116 Page Furnace Manual Includes Installation Data

The 1957 Edition of the Petrochem Isoflow Furnace Manual has just been published. The scope of the 116 page manual has been broadened by the inclusion of data from over 1650 additional installations. While written primarily for operators of Petrochem-Isoflow furnaces, the manual will be of benefit to plant designers, operators and instrument men dealing with any type of heater. Petro-Chem Development Co.

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Tower Packings Are Rated In Bulletin Just Released

Three versatile tower packings are described in separate bulletins just released. Each packing is described completely with its particular application and test results obtained appearing in each bulletin.

These tower packings are called Panapak, Stedman and Goodloe.

Included in these bulletins are tables rating the packings at various reflux rates. Packed Column Corp.

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Tube Cleaning and Descaling Described in New Manual

A new 12-page catalog on a complete line of air motors and tool heads for all types of tube cleaning and descaling operations is now available. The new catalog is intended as a complete manual of operation, including complete parts data and application recommendations on the various types of motors and cutter heads. Gilmans, Ltd.

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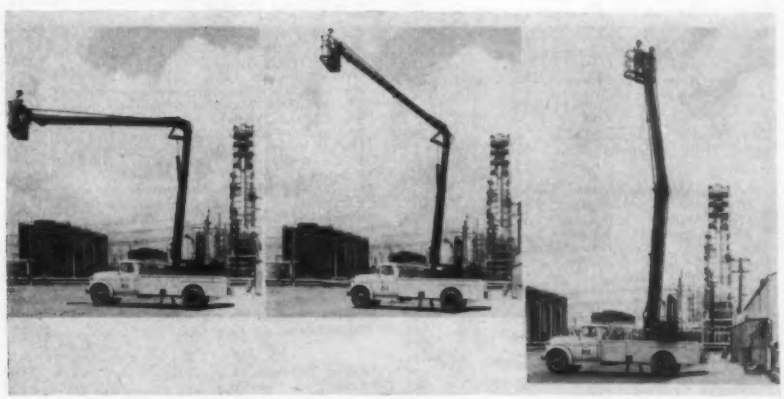
Vapor Fractometer Provides Continuous Process Analysis

An industrial vapor fractometer, extending the widely-used versatile and simple laboratory gas chromatography technique to continuous process stream analysis, has been introduced.

The new instrument has been field tested on such typical applications as the analyses of butadiene product and raw material, alkylation feeds, ethylene, chlorinated hydrocarbons and general refinery streams containing both olefins and paraffins from methane through pentanes and pentenes. Other particularly promising applications include the analysis of synthesis gases used in the manufacture of ammonia, acetylene, methanol and ethylene oxide.

Unusual design features of the model 184 analyzer are a heat exchanger which insures thermal equilibrium between sample and carrier gas, and a unique teflon dryseal sampling valve which accurately meters the sample volume and avoids adsorption effects of lubricants. Perkin-Elmer Corp. **Circle E29 green card, last page**



'Giraffe' From Mechanical Zoo Has 50 Foot Neck

This is the 'Giraffe,' mechanical variety, a highly trained and useful industrial species, according to the results in the short time it has been used at Esso Standard Oil Co.'s refinery in Baton Rouge, La. Its hydraulic neck stretches up to 50 feet in the air and swings around in a full circle, eliminating the erection of scaffolds on many types of jobs, says Esso Standard. The equipment is actually named "the Giraffe." The two Esso employes in the photo, operating the controls from their perch in mid-air, show how the equipment can lift them to various working levels. Pitman Manufacturing Co.

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309e	311	312	313	314	315	316	317	318	319	320a	320b	321	322	323	324"	325a	325b	326	327
328a	328b	329	330	331a	331b	332a	332b	332c	332d	333a	333b	334a	334b	334c	334d	339	340		

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309e	311	312	313	314	315	316	317	318	319	320a	320b	321	322	323	324	325a	325b	326	327
328a	328b	329	330†	331a	331b	332a	332b	332c	332d	333a	333b	334a	334b	334c	334d	339	340		

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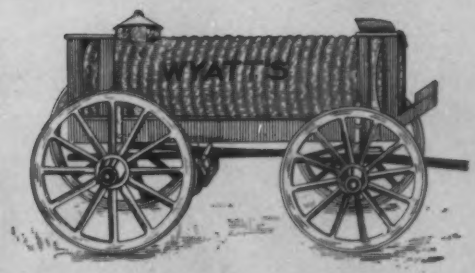

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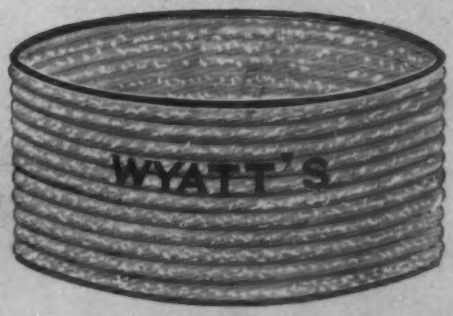

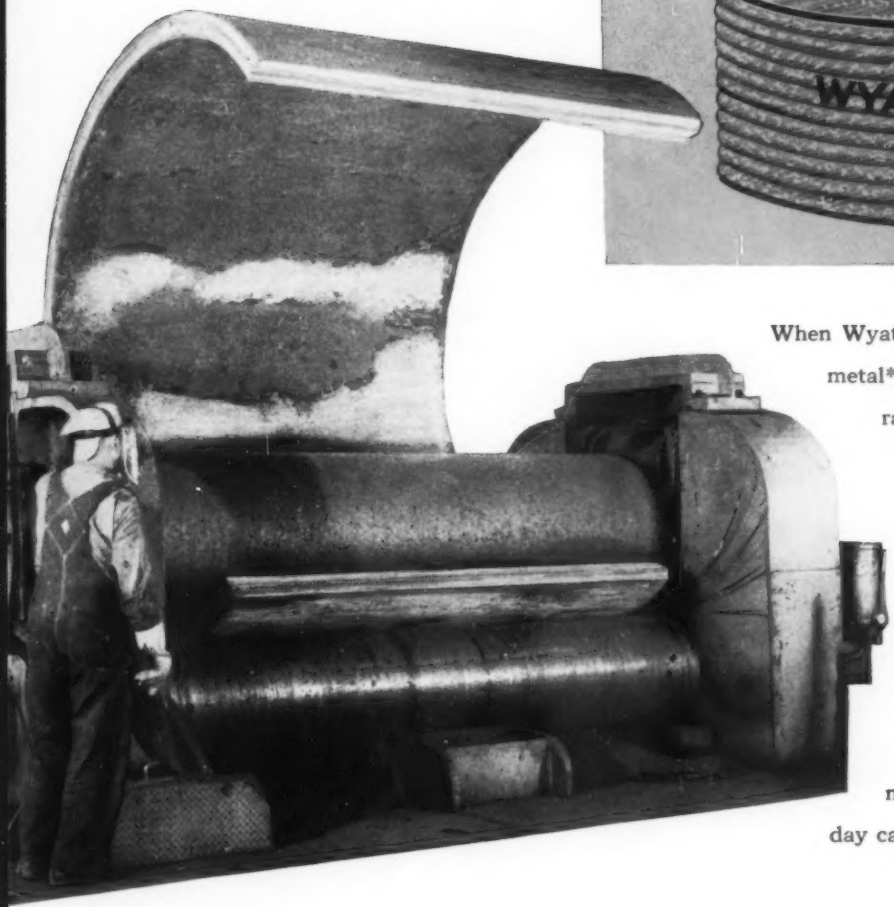

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